PROCEEDINGS

OF THE

COTTESWOLD NATURALISTS' FIELD CLUB

VOLUME VIII

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CONTENTS

CORRIGENDUM.

Vol. VII, Pl. IV, fig 4, pp. 274 and 279—For *Nerinæa Simplex*, read "*N. Calcarea.*" It appears that the name *N. Simplex* was given to another species by DESLONGCHAMPS, in 1849.

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Cotteswold Naturalists' FIELD CLUB

For 1881—1882

President,

SIR WILLIAM V. GUISE, BART., F.L.S., F.G.S.

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Honorary Secretary.

WILLIAM HENRY PAINE, M.D., F.G.S., F.M.S.

Contents.

JOHN BELLOWS, GLOUCESTER

Address to the Cotteswold Naturalists' Field Club, by the President, Lieut.-Colonel Sir William V. Guise, Bart., F.L.S., F.G.S. *Read at Gloucester, April 19th, 1881.*

Gentlemen,

The return of Spring, after a Winter of unusual duration and severity, summons anew the Cotteswold Field Club to those annual rambles which, for thirty-five years, have contributed so largely to the enjoyment and instruction of its members.

Since we last met the Club has to lament the loss, by death, of Mr. John Jones, one of its earliest members, and one who, by the valuable papers he contributed to our "Transactions," has made a mark in our annals, with which his name will always be honorably associated.

Jones was in many ways a remarkable man. He came of a good old yeoman family, settled at Brockworth, near Gloucester, where his father carried on business as a tanner. At 12 years of age John Jones ran away to sea. He had previously been at a school at the Blackfriars, in Gloucester, kept by a Mr. Stephens, where he numbered among his associates the present John Powell, Q.C., and formerly M.P. for Gloucester. He was for some years at sea, knocking about in the Mediterranean, where he picked up a considerable acquaintance with the mercantile languages of that region. He possessed an extraordinary capacity for acquiring language, in the exercise of which he took great delight; and after his return from sea he devoted much time to the study of modern languages, in many of which he acquired great proficiency. With this love of language he combined an equally ardent one for the pursuit of natural science in all its branches, but more especially of geology, into which he brought to bear all the

qualities of his discerning mind and his powers of patient observation. He joined a body of youths at Gloucester who had formed themselves into what they called a "Philomathic Society," where JONES occasionally lectured on scientific subjects. After an attempt to obtain some settled occupation in London, he returned to Gloucester, and got employment in the Docks. Here, without neglecting his business, he worked steadily at his favorite pursuits, Natural History, Geology, Heraldry, &c., and these brought him into communication with many of those in the county who were imbued with similar tastes. He became an active member of the Cotteswold Club, to which he acted for a time as Secretary, and contributed some valuable papers to its Transactions.

The first mention of JONES in connection with the Cotteswold Club is at p. 30, Vol. I., in the Address of Sir THOMAS TANCRED, where he is named as having been present at the Winter Meeting at Gloucester, on January 18th, 1849.

In the Appendix to Vol. I. is a letter signed "JEEMS NICKS." This humourous effusion was written by JONES, as a specimen of the Gloucestershire dialect, of which it is an admirable illustration.

At the end of Vol. II. is a paper "On *Rhynchonella acuta* and its affinities."

In Vol. III.. p. 63, is a "List of the Land, Fluviatile, and Lacustrine Shells found in and near the county of Gloucester."

At p. 81 "On *Gryphæa incurva* and its Varieties."

At p. 128 "On the Natural History, Geology, &c., of Sharpness Point District."

At p. 157 "List of Reptiles found in Gloucestershire."

At p. 191 "Correspondence between JOHN JONES and R. F. TOMES on the position of *Gryphæa incurva* in the Lower Lias at Bridgend.

Vol. IV., p. 175, "Section of the Transition Beds of the Old Red Sandstone and Carboniferous Limestone at Drybrook, in the Forest of Dean," by JOHN JONES and W. C. LUCY.

At p. 194 "Remarks on Drybrook Section."

Vol. VI., p. 191, "Notes on Sherston Magna."

Jones ultimately removed from Gloucester, and resided for a time in Belgium, from whence he went to London, where the latter years of his life were passed. He led there a very secluded life, spending most of his time in the British Museum, where he obtained employment in transcribing ancient documents, in the reading of which he had attained to great proficiency. He died on the 5th of January last, at the age of 63.

Besides John Jones, the Club has to lament the loss, by death, of old and valued friends in Dr. Evans, Rev. A. M. Brown, and R. W. Hale.

I have the authority of our invaluable Treasurer and Hon. Secretary, Dr. Paine, to report that the financial condition of the Club is sound and satisfactory; and that, notwithstanding our losses by death and secession, our numbers are well maintained.

ANNUAL MEETING.

The Club held its Annual Meeting on Tuesday, 20th April, 1880, at the Spread Eagle Hotel, Gloucester. The President read his address, after which the officers of the Club for the ensuing year were chosen when you again did me the honor to elect me as your President, with Mr. T. B. Ll. Baker, Dr. Wright, F.R.S., and Mr. Lucy as Vice-presidents, and Dr. Paine as honorary Secretary.

Dr. Wright then brought under the notice of the Club several fossil organisms believed to be new to science. Of these the most remarkable was a new Brittle-star obtained by Professor Buckman from the Calciferous Grit of Sandsfoot Castle near Weymouth, named by Dr. Wright *Ophiurella nereida.* The example was finely preserved in what appeared to be a nodule of clay ironstone. Scarcely less interesting was a portion of a crustacean believed to be previously unknown, a "*Pseudo glyppœa*" from the Inferior Oolite of Leckhampton-hill: this the learned Doctor proposed to name "*P. Guisei*" in honor of your president. A new and very beautifully preserved "Urchin" (*Hemipedina)* from the upper beds of the Inferior Oolite of Birdlip-hill was also exhibited.

Mr. Edward Wethered exhibited an eyeless fish (*Amblyopsis*) and a crustacean likewise without organs of sight, taken by the exhibitor at a distance of eight miles under ground in the Mammoth Cave of Kentucky. These afford a striking instance of the non-development of unused organs. The absence of visual power in animals whose lives are passed in darkness was further illustrated by Dr. Day in the case of a small fish (*scopelus indicus*) which is an inhabitant of the profound abysses of the Indian ocean, where no light can penetrate. This animal has the eye largely developed, but in order to supply the light which is absent in those sunless depths, it bears along the dorsal ridge a series of luminous specks which are believed to act as lanterns. They are found, like true eyes to possess a cornea and an aqueous humour, and behind all are cells which are supposed to have the power of generating light.

The First Field Meeting of the Club for the season was held on Thursday the 20th May. The rendezvous was at

BERKELEY ROAD STATION.

A visit to the Silurian up-thrust at Purton, which formed part of the programme was necessarily abandoned, by reason of the tide in the Severn not serving. The party therefore proceeded to examine the Section in the Middle Lias opened up by the large quarry of Tait's Hill. The Middle Lias here, as at many other points along the Cotteswold range, is readily distinguished by a sort of step or shoulder, formed by the resistance offered by the hard rocky band which presents so prominent a feature in the formation to the denuding agencies which have shaped the bays and promontories of that remarkable coast-line.

At Tait's Hill, the Rev. Dr. Smithe in response to the call of the president, proceeded to explain the divisions of the "Marlstone" or "Middle Lias," its geographical position, and its relation to the overlying and underlying beds. Geologists have found it convenient to divide these beds into zones, distinguished by particular Ammonites, inasmuch as these cephalopods are found to have a limited range in time, and

thus to afford convenient data by which to classify the succession of beds. In the "Middle Lias" these zones are distinguished by the following Ammonites in descending order:—The 1st or uppermost zone is that of "*A. spinatus*"; the 2nd that of "*A. margaritatus*"; 3rd "*A. Henleyi*" or "*capricornus*"; 4th "*A. ibex*"; 5th "*A. Jamesoni*"; and lastly that of "*A. armatus*," which rests conformably on the upper beds of the Lower Lias. Dr. Smithe showed how the "Middle Lias" which appears but weakly below Bath, is traceable along the western slope of the Cotteswolds throughout Gloucestershire, and finds its greatest development in the neighbourhood where the party were then assembled.

The rock here proved very fossiliferous, especially on the edges of the fissures, where the fossils were weathered out, and presented to the hammers and chisels of the geologists quite a museum of beautiful forms of life. "*Ammonites spinatus*" was abundant, and thus fixed the horizon as that which is specially characterised by the presence of that Ammonite. But Dr. Smithe, when he visited the quarry in company with Mr. Lucy, in the year 1878, had found "*A margaritatus*" (which distinguishes the zone below) on the same horizon, or even somewhat higher in the quarry than the beds then under review. This produced a lively discussion between those who believe that these horizons do to a certain extent overlap one another, and those who maintain that nature produced these particular organisms as special creations which appeared at a certain point in time and became extinct at a certain other point, when they were succeeded by entirely distinct forms. Dr. Smithe further stated that on the occasion of his visit to the quarry with Mr. Lucy they were so fortunate as to acquire from a quarryman a number of reptilian bones, which proved to be those of an Ichthyosaurus of an undetermined species, but probably belonging to "*I. acutirostris*" of Owen. These have since been deposited in the Museum at Gloucester.

Attention was next drawn to a clay deposit of a peculiar character, which in a finely divided state had insinuated itself into fissures of the rock to a depth of 15 feet from the surface,

and had become solidified into a hard compact substance having a conchoidal fracture. This was referred to a glacial origin and identified with the "Boulder Clay" or "Till" of Pleistocene age—so determined from the large percentage of silica (60 to 70 per cent.) it was said to contain. But to some the evidence seemed hardly conclusive.

From Tait's Hill the party proceeded to Melksham Court, (now a farmhouse,) at the foot of Stinchcombe Hill, formerly a residence of the Tyndale family, and where William Tyndale, the Translator of the Scriptures, is supposed to have been born. Luncheon was here discussed, and then the party, or the larger part thereof, proceeded to mount the steep acclivity of Stinchcombe Hill, while the remainder with the carriages took the road to North Nibley. Stinchcombe Hill is one of the most prominent of those capes or headlands which project from the Cotteswolds into the vale of the Severn, and the prospect from its summit is one which for extent and varied beauty has few equals in any part of the world. By the aid of aneroids its height was determined as being 620 feet. The extreme point of the hill is known as the "Drake stone." It is protected by four lines of entrenchment, and traces of more than one hut circle are visible in its neighbourhood. The term "Drake stone" is believed by Mr. John Bellows to be a corruption from the Welsh "Drych," a sight or spectacle. Its derivative "Drychiant" means prospect; so that in this position it must have signified the "outlook," or "prospect stone." It is known to have been a signal station in mediæval times, and doubtless was so in the time of the Romans, when its beacon fires were visible, not only to the forts along the line of the Cotteswolds, but must likewise have conveyed notice of an incursion of the restless Silures to the camps on the further side of the Severn.

The descent of the hill having been effected, not without difficulty, by reason of the abruptness of the slope and the slippery nature of the short turf that clothed it, those on foot made their way to North Nibley, where they rejoined the carriages and enjoyed a pleasant drive to the Prince of Wales Inn, near the Berkeley Road Station, where, after the heat and

fatigue of the day, an abundant and well supplied dinner proved very welcome.

After dinner the President invited Dr. Smithe to offer some further remarks on the "Middle Lias," to which he responded by describing the zones of life which distinguish the softer beds of the formation. This brought up the vexed question of Development *versus* Special Creations, a question which apparently can never be settled, because the partisans of either theory have no common ground of debate from which to start. The discussion, which was maintained with much animation, occupied the attention of the company until it was time to rejoin the train.

The Second Field Meeting of the Club was held at

ABBERLEY,

on Tuesday, 22nd of June, at which, as I was not present, I am indebted for my report to the pen of one who was more fortunate than myself.

The members assembled at the Worcester Railway Station, and made for Abberley through Ombersley and Witley, to the Hundred-House Inn, at the foot of the Abberley hills. This was made the head quarters of the Club for the day. The Abberleys are a prolongation of the Malverns, and present certain upheavals of trappoid breccia in places which, if not exciting causes of the dislocation of the adjacent strata of "Silurian" and "Old Red," formed lines of departure from which the disturbance abutting upon them took its origin. A better field for the study of intricate points in the physical geology of the past could not be desired; for here the Geologist stands upon an uplift of no mere local character, but one coincident with cosmic forces operating in a certain direction by way of the Malvern range, May Hill, Tortworth, and thence to Antrim, in Ireland. All along the chain are effects well marked by faults, upheavals and axes of disturbance, besides the presence of igneous rocks which have at intervals come to the surface, and speak for themselves in a language understood

by the petrologist, and construed by means of the microscope, the blow-pipe and the laboratory. With this general glance at the physical nature of the country visited by the Club, we return to the starting-point at Worcester.

The journey to the Hundred-House lay through a smiling country; the crops seemed heavy on the red lands—peas were being harvested, hay-making had begun, vetches were being cut, and the air was scented with the fragrant perfume of beans and white clover in blossom, whilst in the hop-gardens women were fixing the bine to the poles, and otherwise taking care for the produce. Omberley Court, the residence of Lord Sandys, and the old church and pretty village, with its timber-framed houses, marked half a stage in the journey, and when further on Witley Court and Park were reached, a division of the party ensued, some lingering to see the fountains playing in Lord Dudley's Italian gardens, whilst others pushed on to the Hundred-House.

The geological party, under the guidance of Dr. Smithe, soon became deeply interested in the remarkable district under exploration. They first examined the fine exposure of Upper Silurian rocks at Walsall quarry. Here were presented to view an imposing series of Upper Silurian deposits, with the characteristic fossils of the Wenlock, Aymestry, and Ludlow beds. The following species were here tabulated, and had there been time to give to the work a more careful scrutiny, the list would have been much longer, though it was noticed that the multiplicity of marine life was due rather to the number of individuals than to the number of distinct kinds of organisms.

The following are the most noticeable:—

Pentamerus Knightii, *Spirifer pisum*, *S. elevatus*, *Atrypa reticularis*, *A. compressa*, *Rhynconella Wilsoni*. *R. navicula*, *R. deflexa*, *Retzia sp.*, *Cyrtoceras levis*, *Pterinea lineata*, *P. Sowerbii*, *Chonetes lata*, *Holopella sp.*, *Strophomena depressa*, *S. englypha*, Encrinite joints and Corals in great abundance.

Mr. Best, agent to the Earl of Dudley, had kindly ordered that every attention should be paid to the Club, and the head

gardener was in attendance, with directions to have the fountains played, and to show the fine gardens and park, the mansion and its chapel, refulgent with gorgeous stained glass of the Renaissance period, and its cupola, with gilt sheathing, glittering like a meteor in the distance.

The park, which is of great extent, has many beautiful conifers and clumps of rhododendron, then in full flower. The tropical conservatory, terraces, sculpture, and artfully contrived vistas, were all greatly admired, as well as the massive gnarled butts of many "brave old oaks," scattered about the demesne, which carried the mind back many hundreds of years into the past.

After the study of the Walsall quarry, at the west foot of the Abberleys, the ascent had to be faced, but the slope was easy, and the summit of 800 feet was soon reached. Here, with the Survey map spread out, the grand extent of the prospect, with its chequered lights and shadows, presented a scene of rare beauty and interest: here met the eye, directly in front, the towns of Kidderminster and Stourport, at the entrance of the Severn valley, each capped with its canopy of smoke, drifting to the eastward, where rose the Lickey hills. To the left of the spectator was the little town of Bewdley, on the silver Severn, and stretching out beyond the Forest of Wyre, shorn of its ancient dimensions, but marking and masking the Shropshire coal-field. Well off to the west, along the sky-line, were the Clee hills—the Brown Clee and its companion the Titterstone Clee—to which our Gloucester streets and roads are indebted for the tough basaltic rock which forms the material of their metalling. In the far distance could be discerned, though dimly, the igneous rocks about Church Stretton, the Longmynd and the Stiper Stones. Eastward of this line arose the Wrekin, with Shrewsbury lying central, Bridgnorth nearer, and from thence the valley winding northwards to Ironbridge and Coalbrookdale. Turning from this glorious and instructive view of Salop, and descending, is seen that aspect of the Malvern range to which the eye of the dweller near Gloucester is unaccustomed, namely, the

fore-shortened appearance which the Malvern hills present as one looks from this northerly direction towards the Worcestershire Beacon.

The dispersed members of the Club met at the table of the inn, partook of an excellent dinner, and, undaunted by a thunder-storm which overtook them on their way, arrived safely at Worcester, and took the train westwards, after a day of much enjoyment.

The Third Field Meeting was held on Tuesday, the 20th July. The fixture was Lydney, with dinner at the Speech House, in

THE FOREST OF DEAN.

The weather was everything that could be desired, and some 40 members with their friends assembled to take part in the excursion. They quitted Gloucester by the Midland Railway, and had the satisfaction—a novel experience to most—of crossing the Severn Bridge, a distance of three-quarters of a mile, on foot; in traversing which they found ample opportunity of admiring that magnificent example of engineering and constructive ingenuity, while the prospect up and down the river was one of rare beauty and interest. Arrived at Lydney town, the party went on to Lydney Park, the residence of Mr. Bathurst. Here they met with a most courteous reception from the proprietor, under whose guidance they proceeded to the Roman Camps, the examination of which constituted the main object of their visit.

There are two camps; one a small one, occupies a projecting knoll, the sides of which have been steeply scarped, and is separated by a deep valley from the larger entrenchment. It is somewhat oval in form, and may, from the salient position it occupies, have been used as a post of observation prior to the Roman occupation. Pottery and Roman coins have been found there. But the fortified enclosure which crowns the adjoining hill is of quite a different character, and reveals in its extent and completeness a Roman station of the most important class. The principal building, which is considered to have been the

residence of the Roman Commander, extends 168 feet north and south, by 136 east and west. Besides this, there are other considerable ranges of building, comprising besides offices, a bath establishment, and a detached building in the midst of the enclosure, believed to have been a temple, in which were found votive tablets inscribed to an unknown, but supposed British deity named "Nodens" or "Nodons," for it is spelt both ways. The remains of tesselated pavements still existing in some of the apartments of the principal building, were laid open for inspection. But unfortunately for the preservation of this interesting structure, it was long neglected and left open to the diggings and grubbings of relic-hunters, until Mr. Benjamin Bathurst, early in the present century, took the subject in hand, and preserved to posterity all that can now be known of this relic of Roman occupation.

The series of coins which have been discovered on the site found a worthy collector and interpreter in Miss Charlotte Bathurst, who arranged and catalogued them seventy years ago. These coins range from Augustus to Honorius, that is, during the whole period of the Roman Empire, embracing a term of 400 years. Of the Emperors Augustus, Nero, Galba and Vitellius, there are but few—one or two of each—but with Vespasian, who died A.D. 69, they become plentiful, thus demonstrating clearly the early occupation of the station.

It is probable that the establishment of the station at Lydney dates from the construction of the "Via Julia," which is believed to have been the work either of Julius Agricola or of his successor Julius Frontinus, which would accord very well with the date of the coins. Agricola was resident in Britain from A.D. 78 to A.D. 84. The "Via Julia" appears to have followed the line of the British Ryknield Street from "Glevum" (Gloucester) to "Venta Silurum" (Caerwent.) It has been partially traced by the late Mr. Ormerod in its course past Lydney and Aylburton. The intermediate connection between this main line of road and the station at Lydney is now lost; but there is said to have been a line of way down the hollow between the two camps which may well have been

that which communicated with the "Via Julia." The subject of Roman roads in the Forest of Dean is one which may well occupy the attention of antiquaries. There are few old roads in the Forest that do not show traces of Roman usage, in the bonding-stones still to be seen in their places, and in some instances portions of the paved way are still preserved. These should be mapped before the encroachments of enclosures have obliterated their traces.

Having completed their examination of the camps the party returned to Lydney Park, where Mr. Bathurst had prepared a very welcome reception. Scant time was there for the examination of the Roman antiquities displayed for inspection, which have been figured in the beautiful work by C. W. King, on "The Roman Antiquities at Lydney Park, Gloucestershire," published the previous year. A glance at the coins, amongst which were a few gold and many silver, sufficed to show their number and importance, and the admirable manner in which they have been arranged and interpreted by Miss Bathurst.

A special train from Lydney conveyed the party by a beautiful route through the Forest to the Speech-House-Road Station, from whence a walk of half a mile brought them to the "Speech House," the chief centre of Jurisdiction under the old Forest and Mining laws. The beauty of the situation is well known, and no more charming locality could be selected for the bourne of a day's outing. Here the travellers found an excellent dinner provided at a very reasonable cost, to which in spite of Mr. Bathurst's hospitality they were prepared to do ample justice; and so the time passed pleasantly away until the exigencies of the hours summoned them to a special train in waiting, which carried them to their destinations after a day most pleasantly and instructively spent.

The Fourth and last Field Meeting of the Club for the season was held on Tuesday, 17th August. The rendezvous was at

MANGOTSFIELD,

where carriages were in waiting for the conveyance of the

party. The route lay through the Frome Valley, by way of Frenchay, Glen Frome, Oldbury Court, Stapleton and Fishponds, to the "Speedwell Pits," on the western side of the Kingswood coal-field. Eight years previously, in the summer of 1872, the Club had visited the Collieries at Kingswood. This excursion therefore may be regarded as complementary to the former, and of especial interest as enabling the visitors to witness the newly-introduced application of compressed air to the ventilation of mines.

In passing through Mangotsfield a halt was made to examine an ancient Manor-house and the Church. The former known as "Rodway Hill House," still retains about it many features of antiquarian interest, but is especially noticeable as having over the entrance-door a stone escutcheon with the armorial bearings of the Boleyn family, of whose connection with the place there is no record.

In the church is a mutilated female figure with the curious mitre-shaped head-dress of the early part of the 15th century. She is supposed to represent a member of the family of Blount of Bitton, who were for many generations the principal proprietors, and whose arms are to be seen on two escutcheons over the western door-way. The arms of Blount as given by Bigland are "Argent 2 Bars Azure, and over all an Escarboucle of 8 rays pometté and floretté Or."

Passing by way of Downend and Cleeve Hill the party reached the beautiful Frome Valley, which they traversed on foot. The Frome river—so called according to a Cambro-British authority from a Welsh word signifying "running water"—takes its origin in, and traverses the "Pennant" sandstone of the coal measures, which forms as important a feature in the Bristol as it does in the Forest of Dean and the Welsh coal-fields. This "Pennant" sandstone forms a deep valley through which the river Frome makes its way amid scenery of no ordinary beauty, in which trees, rocks and water combine to present all that is most pleasing to the eye and most grateful to the feelings. Embowered amongst woods on the stream, is "Snuffy Jack's Mill,"—a favorite subject for artists—so called

from a manufacture of snuff which was formerly carried on there, but the whole course of the stream abounds with picturesque spots on which the eye and the pencil of the artist love to dwell. Its seclusion too, so near to the crowded outskirts of Bristol, comes with a certain surprise on the traveller over that smoke-begrimed district.

Pursuing their way by the route already indicated, the party reached the "Speedwell Pits" which formed the ultimate bourne of their excursion. The splendid air-compressing machinery was first brought under their notice. This power is no new discovery. The compressibility of air was known as far back as the time of Ctesibius, a celebrated mechanician, who lived as far back as 250 years B.C.; its latest application on a grand scale was to the excavation of the Mont Cenis tunnel. It is believed that compressed air when it comes to be thoroughly understood and utilised, will do more for the miner than all the powers hitherto applied or invented. It will be the motor for doing all the hard manual labour; it will supply the "life-giving element" pure air; it will drive the coal-cutting machine, and blast down the coal; it will strike and turn the rock-borer, and it will haul the debris away; it will pump the water, and cool the mine; in short there seems no limit to its utility and adaptibility; it may be said, indeed, to have solved the problem of deep mining. Hitherto the obstacle to mining at great depths has been the increase of temperature, which rises in proportion to the depth penetrated; and it is found that when the heat of the mine equals that of the human body, muscular power can no longer be effectively wielded. This difficulty is overcome by the propulsion of compressed air, which effectually reduces the temperature at the greatest depths. This was realised to-day by those—and they comprised the greater number of the excursionists—who descended the shaft, 500 yards (more than a ¼ of a mile) in depth, and then followed the gallery (nearly a mile in length underground) and found the air throughout pure and the temperature cool and equable.

Having returned safely to bank, the party found at the residence of Mr. Handel Cossham, within a hundred yards of

the pit, a sumptuous cold collation prepared under a tent, with no lack of cooling and sparkling beverages, to which their previous exertions disposed them to do ample justice. After dinner Mr. Cossham proposed in felicitous terms the health of Her Majesty the Queen, which was followed by that of your president, who in proposing the health of their host made reference to his great practical knowledge as a geologist, which he had turned to such good account in unravelling the very obscure and difficult problems of coal-mining—difficulties with which the Kingswood coal-field abounds. In illustration of this point, reference was made to plans of the underground coal-seams hanging on the walls of the tent, by which it was seen how some of the most intricate problems of coal-mining had been grappled with and successfully overcome.

The last toast was connected with the name of their colleague of many years, Robert Etheridge, F.R.S., now occupying the distinguished position of President of the Geological Society of London, a post of honor and distinction, the well merited reward of his own industry and ability, which have placed him at the head of one of the most important scientific bodies in the world. The presence of Mr. Etheridge amongst his old comrades was warmly welcomed. He expressed his pleasure at again finding himself amongst those with whom he had been so long associated. He dwelt with emphasis upon the valuable work done by the Club and embodied in their Transactions, assuring them that in the estimation of men of science the Cotteswold Club held a position at the head of all kindred societies. But while thus awarding so large a measure of praise to the memoirs published in the Transactions of the Club, he expressed an opinion that much of their utility was missed by reason that, as works of reference, they are almost unprocurable—the result of their limited circulation—no copy being found either in the British Museum, or in the libraries of the Geological Society or of the School of Mines; and he strongly advised that this omission should be repaired with as little delay as possible. This I am enabled to say has since been done.

Mr. Handel Cossham read a short paper on "The Pennant Formation in relation to the Bristol Coal-field," in which he remarked that the "Pennant" forms one of the best proofs we possess that the Welsh Coal-field, that of the Forest of Dean, and that of Bristol, are all members of the same family, and were all formed at one period; that all at one time formed one great basin, which time and geological changes have severed into three distinct Coal-fields. These changes have been mainly due to the rent or "fault" now occupied by the river and estuary of the Severn, which has not only separated the Bristol area from that of Dean Forest and South Wales, but has given to it a lateral thrust, which has caused the dislocations which render the Bristol Coal-field so difficult to work.

Lastly a very interesting and instructive paper was read by Mr. Johnson, the superintendent of the pits, "On Compressed Air, and its application to Mining."

The thanks of the Club were voted to Mr. Cossham for having so successfully planned and carried out a most enjoyable Field Meeting, and to Mr. Johnson for his paper; after which the party broke up and dispersed.

The first Winter Meeting of the Club was held in the Lecture Theatre of the

SCIENCE SCHOOL IN GLOUCESTER,

on Wednesday, 9th of February, in the present year, when a paper was read by Mr. Witchell, of Stroud, on the "Præ-Cambrian Rocks of St. David's." Those who read—and what Geologist does not?—*The Quarterly Journal of the Geological Society*, will have enjoyed the advantage of studying the series of rocks under consideration, in the memoirs of Dr. Hicks, a local Geologist, to whose researches is due the separation and classification of this area of obscure and little-known rocks. Mr. Witchell had lately had the advantage of traversing the ground in company with Dr. Hicks, and it was with the desire of introducing to the notice of the Cotteswold Club the nature and sequence of these rocks that Mr. Witchell read his paper, which was well illustrated by maps and diagrams.

The Præ-Cambrian series of Pembrokeshire is divided by Dr. Hicks into three groups, which in descending order are named "Pebidian," "Arvonian," and "Dimetian." These, which consist mainly of altered or metamorphic rocks, are wholly devoid of fossils. They are overlaid by the lowest "Cambrians" or "Harlech Grits," from which they are separated by a thick bed of conglomerate, which is deposited upon them uncomformably. This bed of conglomerate is shown to be persistent over great areas; it is described as of many feet in thickness, and as consisting of rolled materials of all sizes, shewing an ancient coast-line, with evidence of great disturbance. The Rev. W. S. Symonds writes—"It is singular that this conglomerate bed should extend so widely at the base of the Cambrians. I have seen it away in the Hebrides, in Sutherland, and in S. Wales, and it occurs along the same line in the Malvern hills."

The underlying Præ-Cambrian beds have been so altered by heat and pressure, that it is only after long and intimate acquaintance, aided by patient research, that their sequence can be determined: indeed the conclusions of Dr. Hicks have not met with universal acceptance, many Geologists of the highest consideration continuing to regard these deposits as due to intrusive volcanic action.

It is well known that in America and in the north of Scotland there exists a vast thickness of Præ-Cambrian rocks, known as the "Laurentian" series: these are regarded by Dr. Hicks as underlying the Præ-Cambrians of Pembrokeshire and Caernarvon, which he regards as the uppermost beds of the Laurentian series. The question is a very intricate one, and one rendered all the more difficult by the entire absence of all evidences of life, except in the Laurentians of America, where the *Eozoon Canadense* occurs; but the presence in these beds of lime and phosphates, both of which are constituents of animal life, is appealed to as evidence of the existence of living beings on the land and in the waters of that old primæval world.

There was a discussion afterwards, in which Dr. Wright, Mr. Lucy and others took part, having reference mainly to the

life-history of the epoch, and to the strange fact that in the lowest fossiliferous strata, the huge "*Paradoxides*," the giant of his tribe of "Crustacea" (the Trilobites,) should at once spring into existence without apparently any ancestors. Dr. Wright argued that this sudden appearance of new forms of life was the case throughout all geologic history; others, however, maintain that this history is itself imperfect, whole pages and chapters being lost and destroyed; and that it is alike inconcievable and unphilosophic to assume that a crustacean or an elephant came suddenly into existence without any forerunners from whom to take and carry on the lamp of life.

The Second Winter Meeting of the Club was held in the Lecture Theatre of the

SCIENCE SCHOOL IN GLOUCESTER,

on Wednesday the 23rd of February, when a paper was read by Mr. John Bellows, entitled "Notes on certain traces of the British or Celtic period which remain in the Forest of Dean." Mr. Bellows commenced by referring to the well-known building in the centre of the Forest called the "Speech House," the history of which he sketched, and drew attention to the very considerable number of hollies growing about the spot, and to the evident great age of many of them. He then shewed that many superstitions are connected with the holly which have come down from very remote times, when the plant was associated with some idea of sacredness and holiness. The selection of its present site for the "Speech House" was dwelt upon as implying in itself a strong presumption in favour of the spot having been used as a central point of gathering for a period long antecedent to the erection of the present building. Reference was then made to certain personal characteristics still recognisable, and to habits and customs still or of late existing in the Forest, which are probably derived from Celtic sources; and it was shewn that these peculiarities are still preserved in those districts wherein from the nature of the country the Britons found refuge when fleeing before the Saxon

invaders. One of the customs on which the lecturer laid especial emphasis was the division of time by which the Forest Courts were regulated, having their set times not according to our measure of months and weeks, but by periods divisible by the Druidical numbers 3 and 9, as thus:—The Druidical year consisted of 360 days; this divided by 9 gives 40 days, which was the period for the assembling of the Verderers Courts. Not only was this so, there were two other courts higher than the Verderers; these were the Swainmote (or Free Tenants Court,) which was held every 120 days—or *three* times a year—and the highest of all, called the Court of Eyre, which was held every *three* years. In the lower court *three* witnesses were required, swearing with a stick of holly held in the hand: the bounds were perambulated every *three* years: and the Justices in Eyre sat *three* on the bench at the *Triennial* Court.

The above is but the merest outline of the long and elaborate treatment of the subject by Mr. Bellows, who brought to bear on it a vast amount of research, all going to show that in the Court still held in the "Speech House" we have the last vestige, though perfect in itself, of the grand system of the Druids in Britain.

In the absence of Mr. Christopher Bowly, who had intended to read some notes on the archæology of St. David's, Mr. Witchell gave a brief description of the more important objects of interest to archæologists in the neighbourhood of St. David's. These included 10 camps, all formed by making entrenchments across the base of a rocky promontory projecting into a valley or into the sea. Drawings of two cromlects were exhibited, one at Longhouse, the other at St. David's Head; and reference was made to several stone circles in the neighbourhood of that locality, several of which were stated to have an area of 20 feet in diameter.

This was the last meeting held by the Club. There should have been one held in March, but in consequence of the paper promised for the occasion not being completed, that paper will be read at a future day.

The Cannington Park Limestone. *By* HANDEL COSSHAM.

About four miles North-West of Bridgewater there is a patch of very compact crystalline Limestone that has long puzzled Geologists, and has been the cause of many anxious enquiries and some rather warm discussions.

The peculiarly compact form in which it develops, and the almost entire absence of fossils has made it rather difficult to read, and for the last half-century it has almost unanimously been pronounced to be of Devonian age.

Some years ago our late lamented friend Mr. CHAS. MOORE, of Bath, hesitatingly hinted at the possibility of this formation being carboniferous and I know, from personal intercourse with him, that he always had grave suspicions that it would ultimately turn out to be so. But it is to Mr. TAWNEY that we are mainly indebted for a correct reading of this remarkable and interesting formation.

Mr. TAWNEY, in November 1875, read a paper before the Bristol Naturalists' Society in which, after a careful and valuable review of nearly all that had been previously written (1) by Mr. LEONARD HORNER in 1816, who then pronounced it to be Limestone of the Devonian age.

(2) By the Rev. D. WILLIAMS in 1837, who in a paper read before the British Association, argued that it belonged to the *lower portion* of the Devonian.

(3) In 1841 the late Professor PHILLIPS confirmed this view, and contended that this limestone belonged to the same age as the Ilfracombe group.

(4) Sir Henry de la Beche, who also about the same time contended that this rock belonged to the Devonian series, and to be of the same age as the Quantock hills, lying on the South-West.

Up to this period the opinion seemed to be unanimous that the Cannington Limestone was Devonian, but—

(5) In 1851 Mr. Baker, of Bridgewater, expressed doubts on the point and gave some doubtful proofs of the correctness of his views.

(6) Mr. T. H. Payne followed on the same side; but (7) in 1867 Mr. Etheridge contested the views of Messrs. Baker and Payne, and boldly contended for the ancient faith—namely, that the Cannington stone was of Devonian age.

(8) In 1871 Messrs. Bristow and Woodward, in the Geological Magazines, contended that it was carboniferous, and thus raised the issue again. I ought also to say that there are some corals at the Taunton Museum that were said to have been found in the Cannington Limestone, but which Mr. Etheridge and many other eminent geologists had great doubts about.

(9) In 1875 Mr. Tawney did much to settle the controversy, by the exceedingly valuable paper he read before the Bristol Naturalists' Society, in which he claimed to have found *Terebratula Hastata* and *Producta Elegans.*

I was not, however, aware of this valued contribution to the settlement of the controversy, when in August last I was fortunate enough to be able to secure the companionship of our distinguished President, Sir William Guise, and the learned President of the Geological Society, Mr. Etheridge, in a visit to Cannington Park. We paid the visit after the last Field Meet at Lansdown, which those who were present will remember as having afforded a remarkable illustration of Agneous action.

We drove over that splendid field for geological investigation —the Mendip Hills—through the romantic and deeply interesting gorge of Cheddar. In visiting Cannington we had the advantage of the local guidance of an old Gloucestershire man, of rare intellectual culture, Dr. Winterbotham.

Up to the date of our visit, Mr. Etheridge was strong in his belief that the rock we were about to inspect was Devonian, and strong in the belief that no true carboniferous fossils had, up to that date, been found there—though they had been often

sought for diligently by eminent and earnest students of geological science.

We had not been more than half-an-hour at the quarry, however, when a workman handed me a piece of stone which on inspection I thought contained Productus. I brought it to Sir William Guise, and he gave it as his opinion that I was right in my impression; and upon both of us handing it to Mr. Etheridge he, after the most careful examination, pronounced it to be *Productus Scabriculus*—a carboniferous shell that made it certain that we were looking at true mountain limestone.

Since that time I have been fortunate in obtaining the following:—

One Specimen of "Productus Cora,"
" " " "Terebratula Hastata,"
" " " "Productus Semienticulator,"
" " " "Rhynchonella and Spiriferon,"
" " " "Cyathophyllum,"
Sixteen Specimens of "Spirifera Glabra,"
One Specimen of "Chonetes,"

All of which I have taken the precaution of getting Mr. Etheridge to examine and confirm; and I venture to think that we have now evidence sufficient before us to pronounce, without hesitation, that the Cannington Rock is True Carboniferous Limestone. That being so, thereon hangs a tale—

The Mendip chain has hitherto been regarded as the last South-Western development of the carboniferous series. I have always reasoned that as the Mendip chain had been rent in the centre by a protrusion of Volcanic Lava, and as the flanks of that grand range dipped North and South of this volcanic protrusion that divided the range, that probabilities all pointed to there being a coal-field South of the Mendip chain—still, so long as no coal measures, or their associated strata, had been found on the South side of the Mendip Hills, the question remained one of probabilities only. But I venture to say that what was only problematical before is certain now, and that the evidence produced is sufficient to justify the belief that at Cannington we are standing on true Carboniferous Limestone.

Looking at my section you will see that the distance of the Cannington Hill from the Mendip Chain at Bleadon Hill, is about 13 miles. The result therefore of proving the Cannington Limestone to be carboniferous is practically to extend the Bristol coal-field for that distance south of the Mendip Hills, and to make it next to certain that (to use the words of an eminent statesman) we are within "measurable distance" of coal between Bleadon and Cannington, and I venture to think that a trial shaft or boring say at Highbridge, or anywhere east on the line of the river Brue (say near Glastonbury) from 6 to 900 feet deep, would certainly develope a coal-field and ultimately cover that valley with hives of industry, and greatly aid in the material prosperity of that part of the country.

The importance in a national point of view of every extension of our mineral area can hardly be over-estimated. We are exhausting our mineral resources in an almost ever expanding ratio. Our latest returns show that last year we raised nearly 155,000,000 tons of coal or at the rate of nearly 3,000,000 tons per week. With a scarcity of fossil fuel would certainly begin our national decline, and therefore every extension of the area from which the future may draw supplies is important.

I firmly believe that between Cannington Park and the Mendips there is a coal-field that ultimately will prove as valuable, and more extensive than the area that lies between Bristol and the Mendips.

I fear the strata lying south and west of Cannington precludes the hope that we may expect to find coal further south.

The carbonaceous deposits beyond appear to be represented by the older Culures of the Devonian, and the Lignite of comparatively modern times. But for the true carboniferous it seems vain to look below the point under discussion.

But I believe that east of our present coal-fields and extending largely under the German Ocean will yet be found vast and valuable coal deposits that will no doubt tax the geological and engineering skill of future generations.

But that will I hope be found not to baffle the science and enterprise of the future in their efforts to place those resources within reach.

On a Section of Strata exposed in a Railway Cutting at Morse, near Drybrook. By Edward Wethered, F.G.S., F.C.S.

I have to thank Mr. Lucy, F.G.S., for the pleasure of laying before the Cotteswold Club a section of the Strata I am about to describe; but I beg to state that he is in no way committed to any views which I may express on the subject. During last summer Mr. Lucy sent me a specimen of rock from Drybrook, and enquired whether I thought it was Millstone Grit, and if I knew of a large Pebble bed in that formation. I replied that I knew of no such bed, and as to the rock, I was afraid to express any decided opinion upon a hand specimen, seeing that there were petrological characters in connection with it which did not correspond with the millstone grit round Bristol, nor, so far as I was aware, in South Wales. Mr. Lucy shortly afterwards kindly invited me to accompany Sir W. Guise and himself to see the section referred to. However, before going further into the matter, I must briefly glance at some of the geological features around Drybrook, in order to clear the ground for further remarks.

The Bristol, Somersetshire, and Forest of Dean Coal-fields are regarded as outliers of the great South Wales Coal-basin, their disconnection having been effected by the uplifting of the older rocks into an anticlinal curve, which has been subsequently removed by denudation, while the patch of Coal-measures in the Forest of Dean was preserved from erosion by the circumstance of their being laid in a synclinal curve. Their severance from the Bristol Coal-field was brought about in the same way.

By reference to the Geological Survey Map of England and Wales, the Forest of Dean Coal-basin is shown surrounded by the Millstone Grit and Carboniferous Limestone. There is

SECTION OF STRATA

EXPOSED IN THE RAILWAY CUTTING

AT

MORSE, NEAR DRYBROOK

Description of Beds		*Details of Beds.*
SURFACE		ALLUVIAL.
Conglomerate ... 10 ft. 6″		Small Quartzitic Pebbles embedded in a ferruginous matrix. Passes almost imperceptibly into the Sandstone below.
Variegated rose-coloured Sandstone ... ... 12 ft. —		Coarse and well-rounded grains. Bands of Marl irregularly interspersed.
Conglomerate ... 10 ft. —		Large Quartzitic Pebbles, well water-worn. Also Small Quartzitic Pebbles, similar to those in the Old Red Conglomerate.
Rose-coloured Sandstone ... — 8″		Angle of dip 19°
		Mottled Sandstone grains, well rounded. Angle of dip 40°
Not exposed		
Carboniferous Limestone		

however a considerable thinning out in thickness when compared with the Bristol and South Wales Coal-fields. Thus the total thickness of the Limestone at Clifton is about 2900 feet,* in South Wales the formation is from 700 to 1000 feet in thickness, while at Purlieu, in the Forest of Dean, it is about 1102 feet.† The Millstone grit at Bristol may be taken to average 1000 feet thick, that of South Wales 200, whilst at Purlieu it is represented by 41 feet of rock.‡

The Carboniferous Limestone rests upon the Old Red Sandstone, and the passage beds between the two formations are exceptionally well developed in the road from Ross to Drybrook in what is known as the deep cutting. The Old Red Conglomerate is composed of vein quartz pebbles,§ embedded in a ferrugino-arenaceous matrix. A section of the passage beds, with the greater portion of the Carboniferous Limestone which rests upon them, was made by the late Mr. John Jones and Mr. W. C. Lucy, F.G.S., and published in the Club's Proceedings.‖

The section to which I especially desire to draw your attention to-day has been exposed at Morse in the making of a railway to Mitcheldean. The Limestone is not shown in the cutting, nor is the total thickness of the lowest bed of sandstone to be ascertained at this point. As seen in the section which accompanies this paper, the bed consists of a mottled sandstone, built up of well rounded grains of quartz. These average about ·01 of an inch in diameter; they are scratched, and some of them contain cavities. A microscopic section of this grit is represented in Fig. I., magnified 22 diameters. When I first saw this bed a doubt occurred whether it was Millstone grit, as the lithological features were different from anything which I had seen before, and strikingly so when

* Proceedings of the Bristol Naturalist's Society, New Series, Vol. I., Part iii., 1875–6, page 316.

† Memoirs of the Geological Survey, Vol. I., page 129,

‡ Memoirs of the Geological Survey, Vol. I., page 127.

§ Memoirs of the Geological Survey, Vol. I., page 64.

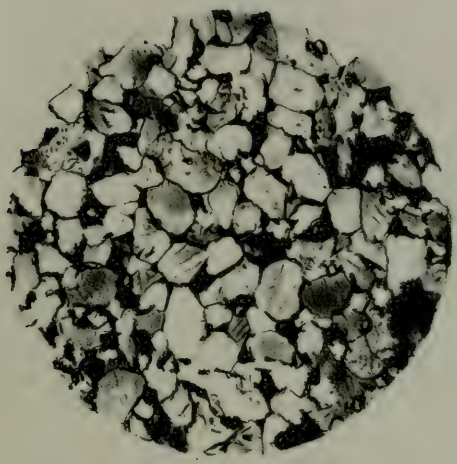
‖ The President's Address, 1867.

compared with the same formation exposed round Bristol. Considering the close proximity of the outcrop of the northern end of the Bristol coal-field, I was certainly not prepared to find so great an alteration in the grit. I may state, however, that lithological characters cannot always be absolutely relied upon for determining the age of rocks, and great mistakes have been made on that account. Throughout geological time we get a recurrence of similar physical conditions, and the lithology of the rocks simply bears evidence as to what those conditions were, and even here we have to take into consideration the changes which have been brought about by the chemical affinities of the substances composing rocks, and by the percolation of water through them. There are however certain special lithological peculiarities exhibited by some rocks which may, at any rate, be taken into consideration over a small area. Thus, in the present case, the Millstone grit of the Bristol coal-field is composed of grains of quartz which appear to cement themselves together (Fig. II.) In the specimen figured, there is a little ferruginous substance to be seen between the grains, but in specimens which I have in my collection, the appearance presented is that of a mass of quartzite, and one has great difficulty in distinguishing the grains, so closely are they cemented by the cohesion of the particles of one grain with another. Again, the grains are sub-angular, a character which is not confined to the Bristol district. Dr. Sorby, F.R.S., in his Presidental address to the Geological Society in 1880,* referring to the Millstone grit around Sheffield, said: "The grains of quartz are, on the whole, extremely angular, and as a general rule show little trace of wearing."

When, therefore, I first saw the bed, under consideration, I naturally hesitated before coming to a conclusion as to its stratagraphical position. The matter was, however, decided on a second visit to the Drybrook section, when I found a *Lepidodendron* in a quarry opened on a bed of a yellow colour, about half a mile from the section at Morse, but in other respects

* Proceedings Geological Society, 1880, page 64.

FIG. I



× 20 DIAMETERS

FIG. II

× 20 DIAMETERS

similar to the mottled sandstone, which I afterwards found occurred immediately under it. A third visit to the locality left no doubt upon the subject, for I discovered another quarry to the left of Euroclydon, the residence of Mr. Brain, (to whom I am indebted for valuable aid in the investigation of the rocks to which I am referring.) Near the top of this quarry was the mottled sandstone underlying the yellow bed before referred to, dipping at the same angle, and composed of grains averaging ·011 of an inch in diameter. Next in descending order was a yellow variegated sandstone of a more compact structure, the grains of which were less rounded, and in size measured about ·007 of an inch; then came a bed of a light grey tint with yellow patches here and there, and the grains averaging ·004 of an inch in diameter. We here get a very good illustration of the change which was taking place in the elevation of the sea floor; a condition of things which ultimately allowed of the growth of that vegetation which gave rise to the Carboniferous coals. First we had a sea in which the Limestone was gradually formed; after a time the sea bottom was elevated, and the conditions became unfavourable to the life of those creatures which built up the Limestone. Sediment was brought down from the surrounding land by water agency, and deposited over the area. At first this sediment was very fine in size, but as the water became shallower the size increased. This is shown by glancing at the measurements of the grains which compose the beds of Millstone grit, and it will be observed that they become of larger dimensions as we pass upwards in the section.

The examination of the quarry near Euroclydon enabled me to get the angle of dip of the beds, which I put at 40° and which it was impossible to ascertain in the railway cutting, though it was apparent that the angle was steep. In the section of the Carboniferous Limestone made by Messrs. Jones and Lucy, the dip is given as varying from 22° to 32°. In a supplementary section kindly given me by Mr. Lucy, the dip of the beds higher up in the formation is put at 36°. If, therefore, we take Mr. Lucy's angle of 36° for the Limestone, and mine

as 40° for the Millstone grit, there is only a difference of 4°, and the lowest beds of the grit are not exposed.

Resting on the mottled bed of Millstone grit in the Morse railway section, comes a rose coloured sandstone of about eight inches thick, composed of well rounded grains of quartz, decomposing felspar and mica, and dipping at an angle of 19°. Over this bed, resting upon it conformably, comes another chiefly made up of large quartzitic pebbles, some of them lithologically corresponding to the Caradoc Sandstone of the lower Lickey Hills, Worcestershire. There is also a second pebble which is identical with those in the Old Red Conglomerate. I am not aware that a Pebble bed, such as the one here described, has been observed elsewhere in the Forest of Dean, which would certainly have been the case had it belonged to the Millstone grit.

The Pebble bed passes somewhat abruptly into a coarse variegated Sandstone which rests upon it at the same angle of dip, and like the 8-inch bed below is composed of well-rounded grains of quartz, decomposing felspar and mica. A section of this rock is given in Fig. III. magnified 22 diameters, and a fragment of Mica from the same in Fig. IV. magnified 130 diameters. The sandstone is irregularly interspersed by layers of marl or kaolin.

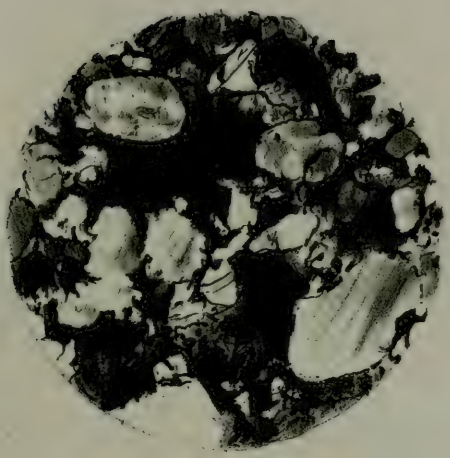
Resting on the last bed comes a small Pebbly Conglomerate, the pebbles being well rounded and embedded in a highly ferruginous matrix.

This ends the section, the small Pebble bed being capped by alluvial deposit. And now arises the question, whether the mottled sandstone, and the beds which underlie, are of the same age as those which rest upon it at a different angle of dip.

In reasoning out this problem, the first possibility which suggests itself is, as to whether we have come across the old river bed which Sir Charles Lyell described as running through the Forest.* The same phenomenon is also referred

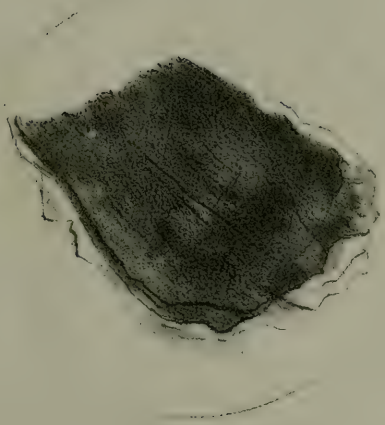
* Elements of Geology, p. 510.

Fig. III



× 20 diameters

Fig. IV



× 130 diameters

to by the Rev. W. S. Symonds, F.G.S., in the "Record of the Rocks."* He says: "In one of the coal seams called the 'High Delph' is an old river bed filled with sand, clay and pebbles. It is known by the name of 'The Horse,' but is different from the 'horses' of the northern coal-fields, which are merely faulted rock masses or trap dykes, and not old coal river channels." These remarks of Mr. Symonds induced me to submit the Drybrook pebbles to him with the view of ascertaining whether they were similar to those found in "The Horse." His reply was that they were not, but that they reminded him of the Trias pebbles which occur at Budleigh Saulterton. This quite coincided with my first idea as to the age of the Pebble bed, and on comparing with the quartzites from Budleigh Saulterton, I find a great resemblance.

To sum up my reading of the section at Morse, (1) I regard the difference in dip between the mottled sandstone and the beds which rest upon it, as evidence of unconformability. (2) It is always unsatisfactory to attempt a diagnosis of the age of rocks without fossils, but judging from the lithological evidence I have adduced, the pebbles seem to me to be thoroughly Triassic, and may possibly be correlated with those at Budleigh Saulterton,† and the beds which follow with the lower portion of the Keuper. In short, I am disposed to regard the beds which lie above the mottled sandstone as an outlier of the Trias formation.

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* Record of the Rocks, p. 388.

† I am aware that Silurian fossils are found in the pebbles at Budleigh Saulterton, but they are not numerous.

On the Minerals of Gloucestershire, with part of the adjacent Counties of Somerset and Worcestershire, compiled by Mr. W. C. Lucy; *also list of Derived Rocks found in the Northern Drift Gravel over the same area, by* Mr. W. C. Lucy.

Last year I was requested by Mr. C. J. Woodward, F.G.S., of the Birmingham and Midland Institute, to supply him with a list of the Minerals of the County of Gloucester, for a new edition of a work on the Mineralogy of England. Through the kindness of Mr. Wethered, Mr. Fryer, and Mr. Brain, I was able to send him a part of the following information, to which corrections and additions have since been made. I have now added a valuable contribution from Rev. Dr. F. Smithe, F.G.S., of Churchdown.

Minerals from the neighbourhood of Bristol. By Edward Wethered, F.G.S., of Cheltenham.

Name of Mineral	Locality	Geological Formation
Hæmatite	Clifton, Winford, Weston-super-Mare, Mendips, Frampton Cottrell, (in the Pennant Grit)	Dolomitic Conglomerate where it is in contact with the Carboniferous Limestone. In "Pockets" in the Limestone. Forms workable deposits in the fissures of the Pennant Grit of the Middle Coal Measures
Göthite (Crystals of a Hydrous Peroxide of Iron)	Clevedon	Dolomitic Conglomerate, only in small quantities
Yellow Ochre	Weston-super-Mare, wherever iron ore is found in "Pockets" in the Mountain Limestone	Weston-super-Mare, Mendips, etc.
Ironstone Nodules and Black Band Ironstone	Easton, Bedminster, Kingswood	Lower Coal Measures
Malachite	Clevedon	Dolomitic Conglomerate, only in small quantities
Galena	Mendips, Clevedon Shirehampton	In Dolomitic Conglomerate and Mountain Limestone fissures

Name of Mineral	Locality	Geological Formation
Manganese	It is difficult to define special locality, as it is to be found in most rocks, especially the Carboniferous	Carboniferous Trias
Celestine, Massive and Crystalline	The Crystalline variety at Clifton The Massive variety in the neighbourhood, at Bedminster, &c.	In Mountain Limestone cavities In oval or round masses at the bottom of the New Red Marl
Barium, in the form of Heavy Spar (Sulphate of Barium)	At Clifton and the neighbourhood	New Red Marl
Baryto Celestine, recently discovered, the only known place in England	Clifton, in the Oakley Road, when digging foundations for building	New Red Marl
Selenite	Various, generally where Celestine occurs	Triassic, Rhætic and Liassic
Calcite	Clifton	In the cavities of the Mountain Limestone
Dolomite	Clifton, Portishead, Clevedon, Westbury	Trias
Quartz, massive, and crystalline, chiefly the latter—"Bristol Diamond"	Clifton Kingswood	Dolomitic Conglomerate Coal Measures (Lower) in nodules of Clay Ironstone
House Coal	Pucklechurch Yate Kingswood Easton, Bedminster	Upper Coal Measures Lower Coal Measures Middle and Lower Lower Coal Measures
Gas Coal	Pucklechurch	Upper Coal Measures
Steam Coal There is also the small patch of Coal Measures at Nailsea	Yate, Kingswood Easton, Bedminster	Lower Coal Measures
Brick Earths	Kingswood New Red Marl	Recent Bedminster
Fire Clay	Pucklechurch Kingswood, Yate Easton, Bedminster	Coal Measures
Mica	Various	Disseminated in the Pennant Grit and Old Red Sandstone
Silver	Mendips, Clevedon Shirehampton Walton	In the Dolomitic Conglomerate and Limestone, associated with the Galena Traces in the free state in Carboniferous Limestone
Gold, traces of	Walton	Carboniferous Limestone

The two last metals were discovered by the late Mr. STODDART, (see paper read before the Bristol Naturalist's Society, Vol. II., Part I., 1876–7. New Series.) He found in 100 parts of the Limestone ·003 of Silver. Mr. MERRY, of Swansea, has verified Mr. STODDART's observations as to Gold ; he found three grains per ton.

Authority—Mr. W. H. FRYER, *Coleford.*

Calcite (Iceland Spar)	Forest of Dean	Mountain Limestone
Do. (Stalactite) ...	Do. ...	Do.
Do. (Satin Spar) ...	Do. ...	Do.
Dolomite	Do. ..	Do.
Quartz	Do. ...	Millstone Grit, &c.
Mica	Do. ...	Upper beds of Old Red Sandstone
Göthite	Do. ...	Coal Measures
Limonite	... ...	Mountain Limestone
Wad (Impure Binoxide of Manganese)	Do. ...	Millstone Grit
Calamine	Do. ...	Coal Measures
Galena	Do. ...	Do.

Extract of a Letter from MR. W. BLANCH BRAIN, *St. Annals, Cinderford.*

The principal Mineral in the Forest of Dean is the Red Hæmatite Iron Ore, which is found in Lodes (locally termed Churns,) and contained in a Rock called by the miners the Creese Stone, and which is situated above the Mountain Limestone. This Ore is extremely valuable for Steel making, being perfectly free from Phosphorus. It is to be found in the lower basin of the Forest, which extends throughout the Forest, and can be seen to the best advantage at the following mine works, viz. :—Wigpool, Edge Hill, St. Annals, Buckshaft, and Shakemantle.

There are some Argillaceous Ores which occur in the Coal Shales, but these have not been worked to profit to my knowledge. They are to be found in small quantities at almost every colliery in the Forest.

I should have said at the St. Annals mine works before alluded to, there is found with the Red Hæmatite Iron Ore a beautiful Ochre.

In the lowest Coal Seam called the Hildelph Vein occurs a small quantity of Lead, yielding a low percentage of Silver.

A quantity of Iron Pyrites (locally termed "Dogs," because they form blocks like Stone) is to be found in a Vein of Coal named the "Twenty Inches." The Pyrites are very detrimental to the Coal (being very heavy, and have to be cut out,) and the former is insufficient to guarantee a manufacture of Sulphur, although such a process has been contemplated.

The above, together with the several Veins of Coal, I believe, constitute the whole of the Mineral commercial products of the Forest of Dean, with the exception of an excellent Fire Clay, which is found just above the Hæmitite series.

Our Clays are rich in Aluminium, and I have struggled hard to extract it on a cheap principle by means of an Electrical Furnace (before Dr. Siemens introduced his,) but have hitherto only partially succeeded.

Minerals of Gloucestershire. By Dr. Fredk. Smithe, F.G.S.

Orthoclase	Basalts	Charfield
Plagioclase	Do.	Do.
Augite	Do.	Do.
Magnetite	Do.	Do.
Olivine	Do.	Do.
Porcellanite	Do.	Do.
Chlorite	Do.	Do.
Chert	... ...	Damory, Tortworth
Prehnite	Amygdaloid trap ...	Damory and Charfield
Muscovite	In clays and marlstones	Churchdown
Calcite	Throughout ...	Do.
Pyrites	Do. ...	Do.
Do.	Rhætic ...	Garden Cliff, Westbury-on-Severn
Marcasite	In clays and marlstones	Churchdown, &c., &c.
Mispickel	Rhætic ...	Garden Cliff, Westbury-on-Severn
Lignite	M. Lias, &c. ...	Churchdown, &c., &c.
Chalybite (Spathose iron of Phillips) ...	Spinatus Beds ...	Churchdown
Bole	... ...	Tate's Hill, Churchdown, &c.
Limonite	... ...	Churchdown
Clay Ironstone	... ...	Do.
Göthite	Coal Measures ...	Iron Acton
Rhodonite	M. Lias	Gretton, Churchdown
Dolomite	... ...	Thornbury
Selenite	Lias	Churchdown
Bitumen	U. Lias	Do.
Arragonite	Lias	Do.
Alunogen	U. Lias, Shales ...	Do.
Copralites	Rhætic	Garden Cliff, Westbury, & Hock Crib
Gypsum	Trias	Garden Cliff, Westbury
Chalcopyrite	Rhætic	Garden Cliff, Westbury, &c.
Travertine	Oolite and Lias ...	Cotteswolds — Dursley, Churchdown, &c.

Notes on Rocks. *By* W. C. Lucy.

These Rocks are derived from other localities and found in the Northern Drift Gravels near to and within a few miles of Gloucester, and generally occurring at heights from 50 to 250 feet above sea level.

Millstone Grit	Felstone
Jasper	Chalcedony
Syenite	Granite
Quartz	
Lickey Quartz (Quartzite)	Carboniferous Limestone
Flint	Chalk (rare)

At Limbury Hill, which is about ten acres of table land formed of New Red Sandstone, all the above rocks are found in the drift with the exception of Felstone; and occurring with them in slabs of various sizes, are the following Fossils:—

Heliolites	Wenlock Limestone
Halysites catenularius ...	" "
Cyathophyllum	" "
Favosites alveolaris ...	" "
Petria bina	Caradoc
Chonetes lata	Upper Ludlow
Orthis elegantula	" "
Atrypa reticularis	Wenlock Limestone
Phacops caudatus	" "
Rhynchonella Wilsoni ...	" "

Also a large boulder of Caradoc, probably from Malvern, 2 ft. long, 1 ft. 6 in. wide, and 3 in. thick, which is now in the Gloucester Museum.

In the Northern Cotteswolds are found, as at Little Woolford, Berrington (near Campden), Goose Hill, Paxford, Compton Scorpion, Blackdown, Barton-on-the-Heath, "The Four-Shire Stone," Aston Magna, Mickleton, &c.—

Millstone Grit	Syenite (Malvern)
Quartz	" resembling Charnwood
Quartzose Pebbles	Greenstone
Hard Chalk	Mountain Limestone, with encrinital stems
Red Chalk (Little Woolford), supposed by Dr. Buckland to be from Spilsby, Lincolnshire	Gneiss
Flints of all sizes, some very large and angular	Hornblende Greenstone
Chert	Brownstone, from the Old Red Sandstone
Granite of many kinds	Permian
Fine grained Trap	Amygdaloidal Greenstone
Mountain Limestone	Chalcedony
New Red Sandstone	Agate
Coal Measure Sandstone, with Stigmaria ficoides	Metamorphosed Slate
Jasper	Saccharoid Millstone Grit
	Greensand

Wherever the Northern Drift occurs at places not mentioned in the above list most of the rocks enumerated are found, and I have several rocks in my collection which I have not been able to get named.

On the Pisolite and the Basement Beds of the Inferior Oolite of the Cotteswolds. *By* E. Witchell, F.G.S.

The deposits known as the "Pea Grit" or "Pisolite," are some of the most remarkable of the Oolitic series, and are peculiar to the Cotteswolds.

The Pisolites are well known to Geologists, but to those who have not particularly observed them they may be described as flat or round grains, varying in size from the 8th to the 3rd of an inch; the flat shape is the more prevalent, but many are elongated or round.

The deposit is of considerable thickness in the neighbourhood of Cheltenham. It becomes thinner at Birdlip, and gradually thins out westward of Stroud.

The observations which I have to make upon this deposit are (1) as to the Structure and mode of formation of the Pisolites; and (2) the Stratigraphical range of the Beds.

(1) The Pisolites are either concretionary structures or rounded fragments of Limestone, or, occasionally, of Coral. They are sometimes referred to as flattened grains, as if they had been compressed at the time they were deposited or before they became hardened. But although they are generally flat, there is nothing in their structure to indicate that those which are now flat were ever globular, but on the contrary, they have every appearance of having been formed very much in their present shape; in fact it will be found, on close examination, that the form of each Pisolite has been determined by that of its nucleus—those which are flat have flat substances for their nuclei, and those which are globular or elongated, have corresponding nuclei. In numerous instances the flat Pisolites have pieces of shell for their centres; occasionally the Pisolite is merely a small univalve or a piece of coral coated over. In nearly

all instances the nucleus is covered with coatings of lime, or muddy deposit hardened into stone, but sometimes the Pisolite is made up of an aggregation of granules similar to those which compose the freestone, and some are merely small fragments of coral or limestone, worn into rounded grains. The coating of the nucleus was apparently a matter of time, as the Pisolites rarely show one coating only; on the contrary the better types show a succession of concentric rings, similar to those seen under a magnifier in the granules of the freestone the mode of formation was probably similar in both instances—the decay of rocks or coral reefs and the lime thrown down on the floor of the sea in the remains of minute organisms, which have contributed so largely to the formation of limestone rocks—or carried down to the sea by rivers and then precipitated, furnished the materials, and mechanical action led to the coating of the erratic fragments which compose the nuclei, and to the formation of the Pisolites.

The Pisolites were probably derived from the north or north-east, as shown in the thickness of the deposit at Cleeve and Leckhampton hills compared with its thickness in the vicinity of Stroud; and it would seem, from the general resemblance in shape and size of the Pisolites, that their formation was regular and uniform. The period of their deposition was of considerable duration, as it appears that in some instances they were left uncovered by subsequent deposits long enough, according to Dr. Lycett, to admit of the growth of protozoa upon their surfaces. The passage of the fragments of shells, coral and other particles which compose the nuclei along a sea bottom covered with a muddy deposit, minute particles of which became attached to the moving fragments as they passed along, might perhaps account for the concretionary structure of the Pisolites. They might have then been heaped up in thick beds where the first deposit occurred, as shown in the sections at Cleeve, Leckhampton, Crickley and Birdlip, but were subsequently spread out beyond those points over a large area, gradually becoming thinner at Stroud, and at length ceasing altogether.

(2) The stratigraphical range of the Pea Grit in the Cotteswolds is considerably greater than has been supposed: it extends from Cleeve hill to Selsley, at least twenty miles, and from the escarpment of the Cotteswolds at the Horsepools to Chalford, at least seven miles, and possibly beyond, but there are no means of tracing it further in that direction. Professor Hull, in his Memoir of the Geological Survey of East Gloucestershire, says the Pea Grit does not extend further towards the south-west than Painswick hill, but this is clearly a mistake. Dr. Lycett says that from Cleeve hill to Birdlip hill would seem to include the limits of the Pisolite upon the western face of the Cotteswolds, and it has not been detected at any point far within the range eastward of a line connecting these two hills.* The sections which I have taken will however show that it extends over the area assigned to it, even supposing it terminates with that area, which is by no means certain.

It is, I believe, the opinion of some of our eminent Cotteswold Geologists that the Pea Grit forms the true base of the Inferior Oolite. It certainly presents the Oolitic structure on an unusual scale, and if not the commencement of the Oolitic deposits, it deserves to be so considered; but we must take the facts as we find them, and it will appear from the second part of this paper that the Inferior Oolite deposits had commenced long before the Pisolites began to form, and that the granular structure prevailed in those deposits.

In the Cheltenham area the thickness of the Pea Grit proper and the Pisolitic beds is considerable, but the measurements hitherto published have, with one exception to be presently mentioned, included the underlying beds, which are not Pisolitic. I make the Pisolite, excluding the underlying beds, but including the Pea Grit proper and the Pisolitic Limestone, about twenty-eight feet at Crickley hill, but at the west end of the quarry the beds are divided by seven feet of Oolite, and are much thicker than in the middle or the east

* Geology of the Cotteswold Hills.

end. At Standish hill the Pisolitic beds are twelve feet, at Selsley hill, Stroud and Chalford they average about three feet, at Rodborough hill they are somewhat thicker.

Fossils from the Pisolite.

CEPHALOPODA.

Ammonites Murchisonæ, Sow.
Nautilus truncatus, Sow.
" lineatus, Sow.
Belemnites spinatus, Quen.
" abbreviatus, Mill.

BRACHIOPODA.

Terebratula simplex, Buck.
" plicata, Buck.
" submaxillata, Dav.
" Sp.
" Whitakeri, Dav.
Rhynchonella Wrightii, Dav.
" decorata, Dav.
" angulata, Sow.
" Oolitica, Dav.
" cynocephala var. with 3 plications
" subtetrahedra, Dav.

GASTEROPODA.

Patella rugosa, Sow.
" inornata, Lyc.
Nerita costata, Sow.
Pileolus lævis, Sow.
Natica adducta, Phil.
Buccinum carinatum, Roem.
Nerinæa oppelensis, Lyc.
" Jonesii, Lyc.
Amberleya capitanea, Munst.
Trochotoma carinata, Lyc.
Pleurotoma fasciata, Sow.
" sulcata, Sow.

LAMELLIBRANCHIATA.

Ostrea gregaria, Sow.
" costata, Sow.
Lima punctata, Phil.
" bellula, M. & L.
" pectiniformis, Schl.
" Lycettii, Wright
Pecten articulatus, Schl.
Avicula complicata, Buck.
Mytilus aspet, Sow. (29)
Perna mytiloides, Bronn.
Pholadomya fidicula, Sow.
Astarte excavata var., Sow.
Goniomya angulifera, Sow.
Pinna cuneata, Bean.
Cardium striatulum, Phil.
" lævigatum, Lyc.
Lucina Bellona, D'Orb.
Trigonia formosa, Lyc.

ECHINODERMATA.

Pseudodiadema depressum, Ag.
Cidaris Fowleri, Wr.
" Bouchardi, Wr.
" Wrightii, Desor.
Diplocidaris Desori, Wr.
" Wrightii, Desor.
Clypeus Plotii, Klein.
Acrosalenia Lycettii, Wr.
Hemipedina Bakeri, Wr.
Stomechinus germinans, Phil.
Hemipedina perforata, Wr.
" Bonei, Wr.
" tetragamma, Wr.
" Waterhousei, Wr.
Polycyphus Deslongchampsii. Wr.
Pygaster semisulcatus, Phil.
" conoideus, Wr.
Galeopygus agariciformis, Forbes
Goniaster obtusus, Wr.
Pentacrinus, Austenii, Wr.
" Desori, Wr.

ANTHOZOA.

Latomæandra Flemingii, E. & H.
" Davidsoni, E. & H.
Axosmilia Wrightii, E. & H.
Thamnastræa Terquemi, E. & H.
Thamnastræa Mettensis, E. & H.
" Defranciana, E. & H.
" fungiformis, E. & H.
Isastræa tenuistriata, E. & H.

The Basement Beds of the Inferior Oolite.

The strata underlying the Pisolite consist of Sandy Ferruginous Limestone beds at the base, a light brown Limestone, sometimes coarse and sometimes fine-grained, in the middle, and beds partaking of a Freestone character in their upper parts. These, with the Pisolitic beds and the Pea Grit proper, have been described by several Geologists, but, judging from the summary descriptions given, the true character of the basement beds has been overlooked. In the "Geology of Cheltenham"* these beds are apparently unnoticed, as the "Pea Grit" is given as four feet only. A section of Leckhampton hill was made by Hugh Strickland,† in which the beds are all included under the terms "Pea Grit" and "Ferruginous Oolite" (Belemnite bed,) and the thickness is given as forty-two feet. The Rev. P. B. Brodie also refers to these beds in a paper "On the Basement Beds of the Inferior Oolite.‡

* Buckman and Strickland, Ed. 1845.
† Published in the "Geological Journal," Vol. VI., p. 242.
‡ "Quarterly Journal Geol. Soc.," Vol. VI., p. 208.

Dr. T. Wright, F.R.S., in a paper on "the Palæontological and Stratigraphical relations of the so-called Sands of the Inferior Oolite,"* gives sections of Pea Grit, the basement beds, and the supraliassic sands at Leckhampton and Crickley, and of the basement beds and sands at Haresfield hill, Frocester hill, and Wotton-under-Edge. In the sections at Leckhampton and Crickley the basement beds are included in the term "Pea Grit," in the other three sections they are simply called Inferior Oolite. As these sections are given rather more in detail than the others, I repeat them seriatim.

The Pea Grit (Inferior Oolite) Leckhampton Hill. Dr. Wright.

		ft.	in.
A.	A brown, coarse, rubbly Oolite, full of flattened concretions, cemented together by a calcareous matrix—when the blocks weather the concretions, which resemble flattened peas—form a very uneven surface. It contains many fossils in good preservation.	12	0
B.	A hard, cream-coloured Pisolitic rock, made up of flattened concretions, with a thickness about similar to those in A. . .	10	0
C.	A coarse, brown Ferruginous rock, composed of large Oolitic grains; it is readily disintegrated by the frost, and is of little economical value. . . . . about	20	0

The Pea Grit (Inferior Oolite) Crickley Hill. Dr. Wright.

A.	A coarse Oolitic Limestone, with large grains, and numerous concretionary bodies, exceedingly hard and crystalline in parts. about	25	0
B.	A coarse Pisolitic Limestone composed of flattened concretionary bodies, which are round, oval, or flattened like crushed peas. about	19	8
C.	A coarse, brown rock, very ferruginous and full of large grains. about	10	0

* Quarterly Journal Geol. Soc., Vol. XII., p. 292.

Section at Haresfield Hill (Beacon Hill)—Inferior Oolite. Dr. Wr.

		ft.	in.
A.	A close-grained Freestone resembling the same bed at Leckhampton, but becoming rather flaggy in the upper part. .	15	0
A1.	A close-grained yellow Oolitic Limestone, quarried for road mending, much speckled with dendritical patches of the peroxide of iron, and containing few fossils. It measures about	12	0
B.	A yellowish sandy rock, separating into large blocks which contain fossiliferous nodules. The fossils are in general well preserved in this bed; it is not used for any economic purpose, and heaps of blocks lie close to the micaceous sands. . .	1	8
C	A brown sandy Oolite, passing into a coarse ferruginous Oolite, containing many fossils not well preserved. Oolitic grains of the hydrate of iron are scattered through the brown calcareous matrix. . . . . 8 to	10	0

Section at Frocester Hill—Inferior Oolite. Dr. Wright.

A.	A fine grained Oolitic Limestone	50	0
B.	A coarse, light, cream-coloured gritty, crystalline Oolite, traversed at intervals by shelly layers extremely crystalline; a great part of the rock appears to be composed of the fragments and plates of Crinoidea, the plates and spines of Echinidæ, and comminuted fragments of the shells of Mollusca. This white rock has a most remarkable lithological character, and glistens brilliantly when lit up by the sun's rays. The shelly and pisolitic seams which traverse this bed resemble those in the pea grit. The surface of weathered slabs disclose numerous microscopic objects; the rock is, in fact, almost entirely composed of organic *débris*. . . . . about	10	0
C.	A hard, fine-grained, Oolitic sandy Limestone, of a light brown colour, lithologically different from B. It contains many fossil shells, which are extracted with difficulty, and passes into a hard yellow Oolite with few fossils. . . . from 8 to	10	0

At Wotton-under-Edge, the lower bed is stated to be represented by a yellow, loose, rubbly Oolite, resting on the Cephalopoda bed.

In addition to these sections, Dr. WRIGHT has made a section of Cleeve hill, which appears in the proceedings of the Club,* in which the beds are thus given :—

	ft.	in.
Hard beds of Pisolitic Oolite	2	0
Buff coloured Pisolitic Limestone	4	0
Roestone, with Pseudodiadema depressum, Acrosalenia, Lycettii, Trochotoma carinata	1	6
Pea Grit, with Ammonites Murchisonæ, Terebratula plicata, T. simplex, Avicula complicata, &c.	30	0
Coarse ferruginous Oolite	5	0
	42	6

In this section also the term "Pea grit" is used to include the greater portion of the lower beds, but an exception is made of the coarse ferruginous bed at the base which is no longer treated as Pea grit.

It seems rather singular that in the Sections under consideration the whole series at Haresfield and the beds B and C at Frocester are not referred to as Pea Grit, although they are in the same Geological position and are petrographically and palæontologically the same as those at Crickley, with the slight variations usual in the beds of the Inferior Oolite. At Haresfield hill the Pea Grit has apparently been overlooked, and this may account for the underlying beds being referred to simply as inferior Oolite. It may, however, be seen in the bank on the east side of the road, at the end of the old workings, about 100 yards from the present quarry.

The character of the lower beds did not escape the notice of Professor T. BUCKMAN, F.G.S., who in a paper on the Oolitic Rocks† gives the following brief section of these beds at Leckhampton Hill :—

Shelly Freestone	10	0
True Pisolite	10	0
Coarse-grained Oolite, more or less pisolitic	13	0
Foxy-coloured ferruginous Oolite, seldom pisolitic	20	0

* Vol. IV., p. 60.

† Quarterly Journal Geol. Soc., Vol. XIII., p. 101.

In this Section the change in the character of the lower beds is distinctly noticed. A more minute description might have led to the correlation of the beds with those at Crickley, Haresfield and Frocester hills, and to the better understanding of the series. Having stated the nature of the work already done in this Field, I now proceed by the following Sections to show the Extension of the Pea Grit and the character of the Limestone beds beneath, in the area between Crickley hill and Uley Bury, including the whole of the Stroud district.

Section at Crickley Hill, near the west end of the quarry, taken by* E. Witchell *and* E. Cornford.

		ft.	in.
1.	Two beds of brown pisolite	4	0
2.		3	0
3.	Brown pisolite of variable thickness, and becoming thinner at the west end of the quarry	5	0
4.	Bastard Oolite. At the West end this bed becomes subdivided by a pisolitic bed, which commences like a thin wedge and rapidly thickens.	7	0
5.	Brown coarse pisolite	5	0
6.	Several beds of coarse Oolite, with layers of pisolite in the partings—the upper beds more pisolitic than the lower.	11	0
7.	Beds of Oolitic Limestone, composed of shelly detritus, fragments of spines of Echinidæ, and Oolitic granules. Nos. 7 and 8 are white; Nos. 9 and 10 are whitish brown.	2	0
8.		2	0
9.		3	0
10.		1	6
11.	Fine-grained Oolitic Limestone.	1	9
12.	Coarse-grained ditto	5	0
13.	Coarse brownish Oolite	2	6
14.	Hard brown compact Oolite	5	0
15.	Beds of ferruginous sandy Limestone, yellowish-brown in colour, resting on the Cephalopoda bed	1	6
15.		1	6
17.		1	3
18.		2	6

The Coral Reef overlying the Pisolite is about eleven feet thick. It does not occur at the point where the Section was taken, but is seen on the top of the eastern half of the quarry.

* In this section the beds shown in that of Dr. Wright are given in greater detail.

Section at Birdlip.

		ft.	in.
1.	Rubbly Freestone	5	0
2.	Pea Grit	5	0
3.	Whitish Oolitic Limestone, containing shelly detritus, fragments of spines of Echinidæ, &c.	12	0
4.	Hard ferruginous sandy Limestone	4	0
	Sands.		

Section at Standish Hill, near Randwick Ash.

1.	Pisolite, disintegrated in part, otherwise concretionary . .	3	0
2.	Several ferruginous beds, with reddish-brown sand in numerous pockets and hollows, giving to the rock a nodular appearance. The beds are Oolitic, and are thickly speckled with large ferruginous grains, and frequently pisolitic. There are layers of ferruginous sand in the partings of the beds—Terebratula plicata, Nerinæac Oppelensis, Aviculata complicata, Lima punctata, &c.	9	0
3.	Light brown Oolitic compact Limestone, with layers of detritus of spines of Echinidæ and fragments of Crinoidea alternating. The detritus is darker in colour than the other parts. . .	4	6
4.	Two beds of white Oolitic Limestone, in some parts resembling the building freestone above the pea grit. The granules are small and the beds compact.	2	6
5.		2	0
6.	Several beds of whitish-brown Oolitic Limestone, composed to a large extent of shelly detritus, broken spines of Echinidæ and fragments of Crinoidea, similar to No. 3.	11	0
7.	Four beds of compact Oolitic Limestone; in parts rough, in other parts fine-grained; the fragments of Crinoidea are numerous.	12	0

The Ferruginous Sandy Limestones are not exposed; there is probably a thickness of not less than nine feet of the lower beds beneath the above. The division between the Pisolitic beds and the Limestones is well shown in this Section.

The Section is taken from the left side of the fault in the north-east side of the quarry.

Section at Ruscombe Quarries, near Stroud.

		ft.	in.
1.	Freestone rubble	10	0
2.	Pisolite. The beds are concretionary, but vary in hardness; some portions are good Limestone. Terebratula plicata and Nerinæa Oppelensis abundant.	3	0
3.	Pea Grit. Sandy, with pisolites.	0	3
4.	Freestone, the Oolitic grains sparingly distributed. A reddish-brown sand in the partings of the beds	10	0
5.	Oolitic Limestone—a very thick bed—hard and semi-crystalline in the upper part, softer near the bottom. Mainly composed of shelly detritus, fragments of Coral, spines, &c., and rather large Oolitic grains; the upper surface plain, and covered with small valves of Ostrea and marks of boring. A good weather-stone. About 16 feet exposed	16	0
6.	Three brown sandy Limestone beds, with layers of yellowish sand between them.	9	0
7.	Cephalopoda bed, containing Belemnites, a few Ammonites, Nautilus, casts of Myacites, &c.	2	0
	Sands.		

To see the whole of the beds in this Section it is necessary to go through the excavations which extend round the angle of the hill. The beds are faulted, but it is not difficult to trace them. The Ruscombe valley or Combe is in a fault, and where the Combe enters the Inferior Oolite it is contracted to a gorge about 100 feet deep: the principal quarry is on the west side of the gorge. A few yards below, and at the back of the cottages, there is an excavation in the sands; and the beds are exposed at intervals round the angle of the hill about 100 yards, where they terminate in another quarry, in which the upper part of the beds shown in the first-mentioned quarry are worked. The first five beds are well exposed in the principal quarry: they have evidently slipped from their base, and are now lying with a dip at a considerable angle towards the hill. This is one of the best exposures of the beds underlying the Pisolite in the neighbourhood of Stroud. The bed No. 5 is remarkable for its thickness, as well as its close resemblance in structure to the planking beds of Minchinhampton in the Great Oolite, but the minute shells appear worn, and as the rock is compact, they are difficult to extract.

The Basement Beds can be traced round the slope of the hill from Haresfield Beacon to Standish hill, and are generally upwards of thirty feet thick. In the slope of the spur, half a mile south-west of the Beacon, they appear in immense blocks upwards of 10 feet thick. In the Bank above, and a few yards to the rear, the beds become Pisolitic, and the Pea grit is exposed. In the Beds near Haresfield Hill the rock frequently contains rather large brown grains, giving to it the character of a Rough Oolite.

In the small quarry at the side of the road leading over the Horsepools Hill towards Scott's Quarry, the junction of the limestone beds with the Pea Grit is shown, and the valves of ostrea are seen on the upper surface of the former. The contrast between the two formations is very striking.

Section in Horns Valley, Stroud.

		ft.	in.
1.	Freestone rubble (will probably be increased in thickness as the quarry is worked back into the hill)	5	0
2.	Pea grit and concretionary pisolite	3	0
3.	Whitish Limestone, the upper surface having pockets filled with ferruginous sand	1	0
4.	Brown Sand, compressed and laminated	0	½
5.	Freestone in several beds having the upper surface smooth with numerous minute valves of oysters adherent; the second bed is 12 feet thick, and is similar in character to the bed No. 5 in the Ruscombe Section, about 20 feet exposed . . .	20	0
6.	Ferruginous sandy limestones, thickness unknown . . .		

Section near Boultons in the Golden Valley, Chalford.

1.	Rubbly freestone	10	0
2.	Yellowish brown beds of pisolitic rag stone, the pisolites weathered and distinct on the surface	3	0
3.	Several thick beds of light brown hard Oolitic limestone, the Oolitic grains irregular, the beds more sandy towards the bottom, where they become a ferruginous sandy limestone .	15	0

The pisolitic beds in this Valley are less fossiliferous than elsewhere. Terbratula plicata and Pholadomya fidicula occur sparingly; but in the lower beds there is a stratum full of Hinnites and Pecten.

Section at "The Pound," Rodborough Hill.

		ft.	in.
1.	Freestone rubble	4	0
2.	Pea grit, the pisolites in marly paste, the whole much disintegrated	3	0
3.	Concretionary pisolite, a brown rubbly Oolite, with flattened pisolites sparingly distributed	4	0
4.	Several beds of rough freestone, the lower bed having on its surface numerous pockets and holes full of ferruginous sand	6	0
5.	Bed of white freestone, upper surface plain with small valves of oysters adherent	2	0

Nos. 2 and 3 contain in considerable numbers, T. plicata Rhynchonella cynocephala, variety with 3 plications, Nerinæa Oppelensis in fragments, and more rarely, Stomechinus germinans, Pseudodiadema depressum, and Acrosalenia Lycettii. One of the beds (No. 4) contains a stratum charged with Nerinæa Oppelensis.

The freestone beds continue downwards, but their thickness cannot be ascertained; their upturned edges can be seen in the road below, and the character of the rock appears to resemble that exposed in the Ruscombe quarries. At Selsley hill, nearly two miles to the west, these beds appear still more developed, and are quarried for freestone: their thickness cannot be less than thirty feet. The Pisolite above appears as marly limestone, with Terbratula plicata, T. simplex, Nerinæa Oppelensis, &c.

The next exposure is in the Buckholt quarry at the top of the old Frocester hill road. In the absence of the Pea Grit, the thickness of the lower beds cannot be measured, but there is a ferruginous bed running along the face of the quarry more than 30 feet above the cephalopoda bed. The next section is the well-known one at Frocester hill. I believe the whole of the freestone in the lower quarry, where the cephalopoda bed is exposed, is anterior to the Pisolite. There is an old quarry of softer freestone higher up the hill, in which the fine section showing the oblique lamination of the beds is seen, and this may be above the line of the Pisolite, if it extended so far, but these beds are, I think, let down by a fault continued from the Combe

below Nympsfield, which cuts through the escarpment between the two quarries. A mile beyond are the quarries near Uley Bury, adjoining the farm yard on Uley hill. There is here a thin ferruginous bed running through the quarry, with from 20 to 30 feet of freestone beneath, resting upon the cephalopoda bed, and which, I believe, are also anterior to the Pisolite. In proximity to the ferruginous bed the freestone is very Pisolitic; the grains are large and flat, and there is much probability that this bed is the termination of the Pisolitic beds of the Cheltenham area.

I think we can see in these sections evidence of the gradual change that took place in the deposits of the Oolitic sea. During the period of the formation of the sands lime appears to have been nearly absent, but with the cephalopoda bed calcareous matter began to be deposited. The succeeding beds indicate an increasing amount of lime; they consist of sandy ferruginous rocks, but each succeeding bed appears to be less sandy and more calcareous until the formation becomes an Oolitic Limestone. In the lowest bed the Oolitic structure can scarcely be observed, but as the rocks become more calcareous, the Oolitic granules appear; they are, however, small and sparsely distributed.

The period of the deposition of these rocks came to an end, and a pause ensued of considerable duration, as shown in the great dissimilarity between them and those of the overlying Pisolite, in the well defined line separating the two formations, in the circumstance of the upper surface of the basement beds having been worn smooth and become covered with oysters, indicating a change of level and probable denudation, and in the sterile character of the basement beds, and the abundance of organic remains which appeared with the ferruginous Pisolitic deposits. The last-mentioned circumstance deserves more than a passing remark. The lower beds are usually nearly destitute of fossils, the few that appear consist of minute Gasteropods, with an occasional Lima much worn; but there is a mass of shelly detritus with small fragments of Crinoidea, Echinidæ, &c. In the Pisolitic beds the fossils are abundant, and usually well

preserved, and the greater part of them appear in these Pisolitic beds *for the first time.* All the circumstances, therefore, point to the distinct character of the two formations. It is true there are occasional thin layers of large grains and shelly fragments in the lower beds, but they also occur in the building freestones, and are not of sufficient importance to affect the general character of the formation. The Pea Grit comes in between the freestones and the basement beds, like a broad wedge, the thick end of which is at Cleeve and the thin end somewhere near Frocester hill, thinning off likewise on its south-eastern side not far from Chalford.

I think we have overlooked these basement beds mainly because our Gloucestershire geologists have regarded the Pea Grit as the base of the Inferior Oolite, in consequence of that term having been used to include not only the Pea Grit proper, but all the underlying beds which are not properly Pea Grit nor even Pisolitic.

I regard these beds as constituting the first stage of the Inferior Oolite, unless the Cephalopoda bed ought to be so regarded. They cover a considerable area, are very persistent in their petrographical features, and can be identified with as much certainty as any of the other beds of the Inferior Oolite. I propose to call the series the Lower Limestone.

On a New Species of Star Fish, from the Forest Marble, Wilts. *By* Dr. Thos. Wright, F.R.S., F.G.S., &c.

Genus.—Uraster—*Agassiz*, 1835.

Body, stellate; rays, five, moderately long, cylindrical or lanceolate, deeply cleft on the under side, fringed below with rows of small, and laterally with larger spines. Skeleton composed of small irregularly-shaped and femur-like ossicula, articulated together in a reteform manner. Upper surface of the body studded with blunt or pointed spines, scattered or grouped together in tufts, and arranged more or less regularly in longitudinal rows. Ambulacral avenues wide, composed internally of two rows of long femur-like bones, spaced out for the four series of tentacula. Anal opening small, sub-central, madreporiform body simple. This genus first appeared in the Lias, and ranged onward through the Jurassic, Cretaceous, and Tertiary periods into our existing seas.

Uraster spinigera.—*Wright*, nov. sp.

Diagnosis.—Rays, five, short, broad, curved and pelatoidal; ambulacral areas wide; margins bordered by a series of small ossicles, which form beaded ridges on each side of the ambulacral spaces. The ossicles support numerous small, short, blunt spines which lie in profusion on the sides of the rays; similar spines appear to have clothed the dorsal surface and are seen "*in situ*" in the twisted portion of one of the rays, as delineated in the subjoined figure, drawn by the late Mr. C. R. Bone, and enlarged two diameters.

× 2

URASTER SPINIGERA, *Wright.*

Dimensions.—Diameter of the disk, one half-inch; length of each ray, one inch; breadth of a ray at its widest part, four-tenths of an inch.

Description.—This beautiful little Star-fish was collected from the Forest Marble, near Road, Wilts, by Dr. H. F. PARSONS, who forwarded it to me for description and figuring. The specimen came into my hands in a very bad state, but by carefully backing up the rock with plaster of Paris, I have given it sufficient support to enable me to develop a considerable portion of its anatomy.

The disk was small in proportion to the width of the rays and the diameter of the Star-fish. The rows of small ossicles which bound the margins of the wide ambulacral areas form an

important character in this species. These bones are longest near the oral aperture, and gradually diminish towards the end of the rays. They form a beaded structure of considerable strength, which supported a great number of small, short, stout spines; these appear to have passed round the sides of the rays and covered the dorsal surface. A few of the spines are seen in the twisted part, which exposes a portion of the upper surface. This spinous condition of the tegumentary membrane has suggested the specific name which I have given to this new Jurassic Star-fish.

The small ossicles which occupied the central portion of the ambulacral areas are absent, and there remains only the vacant spaces they at one time filled in (see figure.)

Affinities and Differences.—This organism differs so much from the other fossil species of the Genus *Uraster* that it may probably prove to be the type of a new genus when more details are learned anent the anatomy of the skeleton, by the discovery of additional materials to work upon. In the meantime I have grouped it with the Urasters, to which it is so closely related by general characters, whilst it differs in some others, as for example, in the presence of the beaded ridge formed by the ossicles which bound and limit the ambulacral areas.

Locality and Stratigraphical Position.—This specimen was obtained from one of the shaly beds of Forest Marble, near Road, Wilts. It appears to be rare, as I can find no record of any other Star-fish having ever been found in the fossiliferous beds of that locality.

The above drawing was very carefully made on wood, by the late eminent artist Mr. C. R. Bone, and engraved by Mr. Lee. It represents the fossil enlarged two diameters, in order to exhibit the minute details of the anatomy of this species.

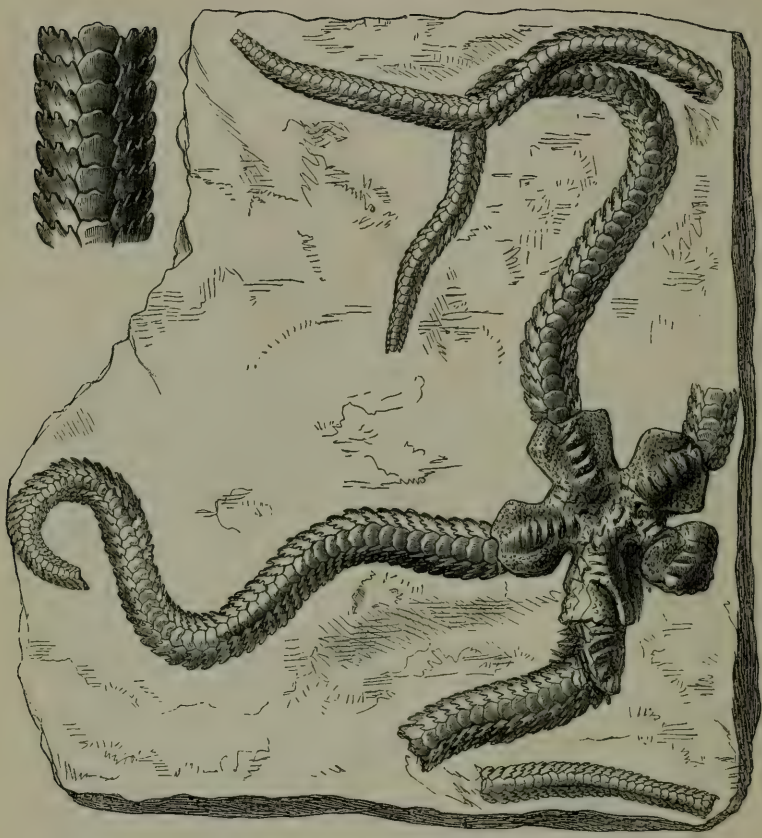
On a New Species of Brittle Star, from the Coral Rag of Weymouth. *By* Dr. Thos. Wright, F.R.S., F.G.S., &c.

Genus.—Ophiurella—*Agassiz*, 1835.

Disk small, membranous, often very indistinct; rays long, slender; lateral ray-plates provided with elongated filiform spines. All the species hitherto found are Jurassic.

Ophiurella nereida.—*Wright*, nov. sp.

Diagnosis.—Disk small, irregularly pentalobed, each lobe consisting of a shield-like elevation formed by the radial plates, which are covered by a tegumentary membrane, closely studded over with small granules; rays five, four times the length of the diameter of the disk. The rays taper a little between the disk and their termination, and consist of numerous highly movable rings, each composed of (1st) a centro-dorsal plate, which with its fellows form a long, smooth, convex continuous chain, flattened at the summit, and laid along the middle of the rings; (2nd) lateral plates bent downwards, and closely clasping the sides of the rays; each plate supports a small tubercle, on which stout, thorn-like spines are articulated; (3rd) ventral plates, which close the ray below, are very much concealed, and carry many short stout spines. One of the arms of this Brittle Star, as it lies on the slab before me (see figure) resembles a marine worm, *Nereis nuntia.* Hence the origin of the specific name I have proposed for this new species.



OPHIURELLA NEREIDA, *Wright.*

This figure was drawn twice the natural size by my artist, Mr. GAWAN, and engraved on wood by Mr. H. P. WOODWARD, for my monograph on the Oolitic Ophiurida. The specimen was obtained from the Calciferous grit at Sandsfoot Castle, near Weymouth, by PROFESSOR BUCKMAN, F.G.S., who kindly sent it to me for examination, and a description of the species for insertion into the "Proceedings of the Dorset Natural History and Antiquarian Club." The specimen belongs to Mr. BUCKMAN'S Collection.

Dimensions.—Diameter of the disk, six-tenths of an inch; length of an arm, two inches and six-tenths of an inch. This is less than what it was in the living state, seeing that none of the rays are perfect up to their termination.

Affinities and Differences.—The fragmentary condition of the disk prevents any very definite conclusions as to the true generic position of this Brittle Star, which, however, agrees better with the diagnosis of *Ophiurella* than any other congeneric form. It has the proportionately small disk, with its upper and under surfaces covered with fine granules; the arms long, compressed and flattened; the lateral and central plates carrying spines, which are specially articulated to the lateral pieces. In all these essential generic characters it agrees well with *Ophiurella.* I know of no figured or unfigured Ophiurida from the Corallian or other Jurassic strata which resembles the subject of this note. The only form occurring to my mind is that of *Ophiurella bispinosa*, (D'Orb.) which was only named, but neither figured nor described by D'Orbigny. *Ophiurella nereida* differs so widely from all other described forms, that it is impossible to make a mistake in confusing our species with any of them.

I am indebted to the kindness of my old friend the Revd. Professor Wiltshire, Secretary to the Palæontographical Society, for the loan of the wood-cut representing this fine fossil, and for which I beg to return him my best thanks.

On a new Astacamorphous Crustacean, from the Middle Coral Reef of Leckhampton Hill. *By* Dr. Thos. Wright, F.R.S., F.G.S., &c.

The *Astacina* form a small interesting group of the Decapodous Crustacea, which are well represented by the common Cray-fish (*Astacus fluviatilis*) so abundant in some of the rivulets of the Cotteswold Hills.

The genus *Astacus* has the external skeleton partly calcareous and partly membranous; the cephalothorax large, and compressed on the sides; the post abdomen flattened; the plastron small and linear; the rostrum a prominent spear-pointed projection; the external pair of antennæ long, filiform, and annulated like a whip-lash; supported on short round stems, making a complete structure two-thirds the length of the entire animal; at the external side of the antennæ is a sabre-like scale attached to the stem; the internal antennules are very short, the two on each shaft are small filiform annulated processes which lie above and external to the long antennæ. The two eyes project beyond the rostrum, each is seated on a moveable stalk, wider at the base, which readily turns the eye in all directions. The first pair of feet are weapons of offence and defence; they are strong instruments, and terminate in a pair of didactyle chelæ, forming forceps, which they use dextrously and with a good deal of disposable energy. The 2nd and 3rd pairs of ambulatory feet are much more slender, and they likewise terminate in a pair of small weak forceps. The 4th and 5th ambulatory feet are about the same thickness, but much shorter, and terminate in short pointed claws. The abdomen consists of six rings or somites; the upper half (*tergum*) of each somite is arched and shield-like, with two lateral wing-like projections (*pleura*); the lower half (*sternum*) is flat and more membranous, and in the female develops a pair of swimmerets attached to the five anterior rings. Behind the

sixth abdominal ring is the telson, with a transverse fold in the middle; and beneath the telson on each side are two broad plates, the highly modified swimmerets of the sixth ring. This structure—the telson in the middle with the two plates on each side—constitute the flapper of the Cray-fish, by the aid of which it executes its retrograde swimming movements.

The fossil Crustacea, which closely resemble our Cray-fish, were first separated from the fresh water genus *Astacus* in 1835, by H. Von Meyer, into the genus *Glyphea*, erected by him for the marine fossil forms of *Astacina*. In 1840 the same author proposed the genus *Eryma*, for a "neue gattung foss. Krebse;" and the genus *Clytia* for another new form; and the genus *Bolina* Münster for a form allied to *Glyphea*. *Glyphea* has great affinities with *Astacus*, from which it is distinguished by having the cephalothorax divided into three regions by well-marked transverse lines. The first pair of feet also, instead of terminating in stout didactyle chelæ nearly equal in strength, have the upper chelæ formed like a bent claw, and the under absent or rudimentary. They are found in the Lias and other Jurassic strata.

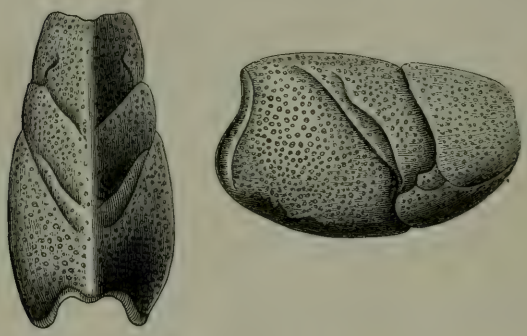
Eryma, like *Glyphea*, has a large cephalothorax, divided by well-marked lines into three regions, the middle being prolonged much backwards. The anterior pair of feet are shorter, and much resemble those of *Astacus*, and like the forceps of our Cray-fish, terminate in a pair of nearly equal-sized chelæ, and by this character alone are they distinguished from *Glyphea*, a circumstance which renders it impossible to determine to which genus a cephalothorax belongs, unless it happens to be associated with the anterior feet or forceps of the animal.

The fossil which I have the pleasure of introducing to the notice of the members of the Cotteswold Club, was obtained from the Fimbria marl of Leckhampton hill, out of the mud-stone derived from the middle coral reef of the Inferior Oolite, in the zone of *Harpoceras Murchisonæ*.

Astacomorphous Crustacea are very rare in our Oolitic rocks, but the well-marked cephalothorax figured above places the fact beyond dispute. I am inclined to place this fossil in the genus

Eryma, from the great resemblance the tergal folds on the carapace have to those in *Eryma elegans*, (Oppel.) from the zone *Cosmoceras Parkinsoni*, of Longwy Moselle. The absence of the anterior legs which would have decided the question of the generic place of our fossil, leaves the determination in doubt which time may possibly soon clear up. It may with equal justice be referred to *Pseudoglyphea*, (Oppel.) or *Glyphea*, (Meyer,) as to *Eryma*, inasmuch as the carapace of our fossil might be placed in either genus; so until the anterior legs with the *chelæ* are found, I propose to call it *Eryma Guisei*, Wr.

Fig. 2. Fig. 1.



Eryma Guisei, *Wright.*

I dedicate this species to our much esteemed and excellent President, Sir William Vernon Guise, Bart., F.L.S., F.G.S., &c., as a recognition of the extreme interest he takes in all Natural History discoveries made in the Cotteswold country.

The cephalothorax of this Astacomorphous Crustacean is divided into three regions, by two well-marked deep lines; the first is compressed on the sides, is narrow on the tergal region, and extends outwards into the rostrum. The groove which divides this from the middle region is very deep, and the entire surface is covered with short, sharp, prominent granules, which are much better shown in a specimen I obtained since the type carapace was figured; this segment is not so deep as the others,

and is slightly inflated at the lower border. The second segment is narrower than the first, and prolonged obliquely backwards; it is separated from the first by a shorter very deep groove, and from the posterior by a longer and shallower furrow. The third region forms nearly one half of the entire cephalothorax, and is bounded posteriorly by a graceful sinuous line which passes round the hinder border, where it played under the first abdominal somite. Fig. 1 gives a lateral view of the cephalothorax of *Eryma Guisei*, Wr., showing the deep transverse lines which divide the carapace into three regions. Unfortunately the outer lamina of the crustaceous covering is absent in the figured specimen, so that the prominences appear as depressions, whilst in another and better specimen lately collected, the entire surface is covered with pointed granulations, which are largest and most prominent on the tergal region and diminish in size on the lower part of the flanks. The lower portion of the middle region has a kind of supplementary inflated portion, and the upper half of its side has a second oblique line, shorter and shallower than the divisional line. The tergal region (Fig. 2) exhibits the three divisions of the cephalothorax, and the oblique course they all take backwards. This view of the cephalothorax of *Eryma Guisei* closely resembles the same region of the cephalothorax in *Eryma elegans*, (Oppel.) (Mittheilungen, Tab. iv., Fig. 7.) a species which is found in the Inferior Oolite of Pipf, near Bopfingen, (Germany.)

The interest attaching to this fossil is great, inasmuch as it shows that Astacomorphous Crustacea were contemporary with the coral builders of our lower Oolites, and that they have come down through Jurassic, Cretaceous and Tertiary times into our present rivers, with a marvellous persistence in their typical structure, and exemplifying in another class of the Articulata that persistency of form in animal types which the Anthozoa, Echinodermata and Mollusca so abundantly afford.

Address to the Members of the Cotteswold Naturalists' Field Club: read at Gloucester by the President, Sir W. V. Guise, Bart., F.L.S., F.G.S., *on Tuesday the 18th of April, 1882.*

Gentlemen,

At this the opening of another season let me begin by offering my warm congratulations on the prosperous condition of the Club, and by the expression of a hope equally warm, that in the season now commencing we may enter with renewed energy on those scientific pursuits and investigations which constitute our *raison d' être;* which have afforded us so much happiness in times past, and by which we have secured no small share of that scientific reputation which constitutes the special honour and glory to be sought by all such associations as ours.

Since our last Field Meeting, this Club, in common with geologic science in general, has suffered a heavy loss in the death of our old and valued associate, Charles Moore, F.G.S., of Bath. Though during the latter years of his life a sufferer from a chronic bronchial affection, which at length terminated his existence, he was to the last an indefatigable worker. His most important discovery, for which he received the public acknowledgments of Sir Roderick Murchison, on the occasion of the meeting of the British Association at Bath, was that of the beds named "Rhætic," which had previously been confused with the upper beds of the "Keuper." Another most interesting discovery made by Moore was that of the infilling from the "Keuper" sea of fissures in the "Carboniferous Limestone," near Frome, of which—with his untiring industry—he passed whole cartloads under his microscope, and extracted thence many thousands of minute teeth, including those of the oldest known of all the mammals, the little "*Microlestes antiquus.*"

The Museum at Bath remains a splendid monument of his untiring patience and industry. This collection, valued at £1,100, has, I am glad to say, been secured, by subscription, to the city of Bath for ever. MOORE's principal contributions to geologic science are to be found in "the Quarterly Journal of the Geological Society," and in "the Proceedings of the Somersetshire Archæological and Natural History Society." He was for many years a member of the Cotteswold Field Club, and was a frequent attendant at our Field Meetings. He died in December, 1881, universally regretted by all who knew him, and leaving a gap amongst scientific workers which will not readily be filled up.

It has only just come to my knowledge that death has, within these few days, removed from among us one of the oldest and most illustrious members of the Cotteswold Club in the person of Dr. JOHN LYCETT, who expired at his residence, at Scarborough, on the 8th of this month. Some years ago he suffered from paralysis, and his health was thereby a good deal impaired, but his intellect remained clear and unclouded, and to the last his leisure hours were occupied with the study of Palæontological science. Dr. LYCETT practised for many years at Minchinhampton, and while there he worked hard at the geology of the district, and his labours found expression in 14 papers contributed to "the Transactions of the Cotteswold Club;" and in the magnificent monograph published by the Palæontographical Society on "the Great Oolite of Minchinhampton," in which he was associated with Professor MORRIS; and in the splendid monograph of "the British Trigoniæ," which, so late as the month of February last, gained for him the coveted award of the Lyell Medal. He published, likewise, a "Handbook to the Geology and Palæontology of the Cotteswold Hills."

The loss of two such men as CHARLES MOORE and JOHN LYCETT is great; but they leave behind them for our imitation a noble example of good work honestly and truthfully accomplished.

During the past season, our Field Meetings were instructive and well attended; and at our Winter Meetings some good papers were read, followed by useful discussions.

THE ANNUAL MEETING

of the Club was held on Tuesday the 19th of April, 1881, at the Spread Eagle Hotel, Gloucester, when the PRESIDENT read his annual address; after which the officers for the ensuing year were chosen, when you again did me the honor to elect me for your President, with Mr. T. B. LL. BAKER, Dr. WRIGHT, F.R.S., and Mr. LUCY, F.G.S., as Vice-Presidents, and Dr. PAINE, M,D., as Hon. Secretary. Dr. PAINE, finding his leisure increasingly taken up with professional work, asked for the assistance of a Treasurer to relieve him of an onerous portion of his duties; on the motion, therefore, of Dr. WRIGHT, seconded by Mr. DORRINGTON, Mr. WITCHELL, who had kindly intimated his willingness to accept the office, was duly elected Treasurer.

Mr. GEORGE MAW, F.G.S., drew the attention of the Club to a curious fact which he had recently observed, which is this: That the tail of a dead vertebrate has, on the setting in of *rigor mortis*, a distinct tendency to be deflected towards the left side. He had first observed this in the case of dead mice caught in mouse-traps, and had noticed the same peculiarity in the carcases of sheep. In 97 per cent. of those noted, the tail was distinctly deflected to the left. Mr. MAW exhibited two series of flowers of *Narcissi* of the daffodil type: one of the several British forms of the "*Ajax*" group, allied to "*Pseudo-Narcissus*," including the Tenby form of "*N. lobularis*," and another form from the neighbourhood of Swansea, intermediate between it and the common form. The other group showed five or six examples of the Spanish "*corbularis*" collected by Mr. MAW from the Sierra di Guadarama in the neighbourhood of the Escorial in Spain, showing an insensibly graduated series in size and colour, down to the minute form of "*N. nivalis*," between which no clear line of definition can be drawn. Mr. MAW then exhibited a selection of his original drawings for a monograph of the genus "*Crocus*," shortly to be published, which will comprise upwards of 70 species from all parts of the world. The exquisite delicacy and beauty of

these delineations, and the microscopic perfection of the accompanying botanical dissections, were beyond all praise.

Mr. Witts exhibited the plan of a chambered long barrow from the neighbourhood of Notgrove, very similar in character to that of the Nympsfield tumulus. In this barrow, which had been at some time ransacked, one chamber remained undisturbed, in which were found the remains of two individuals (the skulls much crushed) together with a flint arrowhead and a curious rude bead, said to be of Kimmeridge Shale, evidently intended for suspension as an ornament or an amulet. A bead of a very similar character is figured in Greenwell and Rolleston's "British Barrows," as having been found in a barrow in the parish of Eyford in this County.

Dr. Wright offered for inspection an Ammonite which he had received from the Rev. W. S. Symonds, with the information that it had been found by Major Thomas on a glacier in Thibet, having fallen from the adjacent rocks. The learned Doctor recognised it as the "*Ammonites biplex*" of Sowerby, one of the characteristic forms of the Coralline Oolite of the Oxford series, and a common Indian fossil. He remarked on the wide distribution of this and other forms in space, and their limited life in time, and dwelt upon the interesting circumstance of the occurrence of the fossil under observation on a particular horizon of Jurassic rock at points so remote as Great Britain and Thibet.

The Rev. W. S. Symonds remarking on the observations made by Dr. Wright upon the Himalayan Ammonites, directed attention to the geographical distribution of "*Cyrena fluminalis.*" This shell, which is only known in Europe in the fossil state, occurs in the old fluviatile drifts of the Thames valley, associated with the bones of the Mammoth and the long-haired Rhinoceros. The same shell is found living in the Nile at the present day, and Mr. Symonds stated that he had in his possession examples taken from glacial streams high up in the Mountains of Thibet.

Some Notes on the Occurrence at Elmore of the Garganey Teal ("Querquedula circia." Linn.)

At the meeting of the Cotteswold Club at Cirencester, last year, it was proposed by Mr. H. J. Elwes that with a view to publication by the Club, a list of the Birds of the County should be supplied to him, to which he invited contributions. With this purpose I offer the following observations on the occurrence in three several years of the above-named rather rare duck.

The latest authorities, Yarrell, in his "British Birds," and Dresser, in his "Birds of Europe," regard this bird as one of very occasional occurrence in this country. Yarrell says, "though I have seen specimens in October, it more frequently makes its appearance in the spring, and then only in comparatively small numbers; these birds are then on their way south." Dresser notes it as rare in the west of England, and not much more common in the southern counties.

In the year 1879, on the 17th of March, a Garganey male and three females made their appearance on a pool at Elmore, on which are kept water-fowl of different kinds. They soon made themselves at home, and became quite tame and fearless, coming to feed with the rest. They remained some little time, going and returning at intervals, but in less than a month they disappeared, and returned no more. In 1880 none made their appearance; but on the 17th of April of last year a pair of Garganeys arrived on the pool. They remained but ten days, and then went away.

In the summer of last year I purchased a pair of Garganeys, domesticated birds, with the carpal joint of the wing removed. The male was shortly afterwards killed by a savage swan. In the month of November last the duck was joined by a strange drake, who associated with her, and mixed with the rest of the water-fowl, coming regularly to be fed, and showing no sign of distrust or timidity. In hopes that the drake might become a permanent resident, care was taken that he should not be

alarmed, and, with that view, no gun was ever permitted to be fired near the pool, which is in an exposed situation, a public path running close by.

As the time approached at which in former years the Garganeys had taken their departure, it became a subject of speculation whether the drake would take himself off,—but that the duck would go too was regarded as impossible, seeing that she was pinioned, and that the piece of water is entirely enclosed with wire netting. But nature and instinct proved too powerful for all hindrances and allurements, and on the 12th of the month both birds were missing, and have not since been seen. How the male enticed the female away is a mystery: it may be that she was not sufficiently pinioned, and could use her wings—but neither were ever seen to fly. Even the drake on his arrival, though at first he would conceal himself under the over-hanging bushes, was never seen to fly. I should fear that the duck, being unable to accompany her partner in his migration, will ultimately fall a victim to vermin.

The First Field Meeting of the Club for the season was held on Tuesday, 17th May, at

CIRENCESTER,

where the recent excavations in connection with the drainage and water supply of the town have opened up many new sources of interest. It is indeed scarcely possible to move ground in the neighbourhood of this great Roman centre without bringing to light some vestiges of the long-continued occupation of the site by the soldiers and citizens of that nation; and these, as they are unearthed, find a fitting resting-place in the noble museum presented to the town by the late Lord Bathurst. To this point the steps of the visitors were first directed, where the large recent additions, in the form of Roman pottery and instruments of bronze and iron were very noticeable. Of these Mr. Bravender has furnished a list,

which comprises no less than 110 pieces of pottery (with the names of the potters,) and others, amongst which are more than 100 pieces of Samian waré of various patterns, and more than 200 instruments and ornaments in metal—mostly bronze. But perhaps the most interesting among the recent discoveries is a stone altar, about three and a half feet high, which now presents an appearance nearly perfect, though when found it was broken into innumerable fragments. It represents a nearly undraped male figure, standing within an arched alcove, crowned with a radiate coronet; a cornucopia rests on the left arm, while the right holds a patera, from which the figure is in the act of pouring a libation on to an altar. On the architrave above is inscribed "G. S. H.V.I.S. L.O.C.," which letters stand for *Genio Sacrum Hvjvs Loci*, (Sacred to the Genius of this place.) Much attention was directed to the curious palindrome or squared words on a piece of painted wall-plaister, which have at different times given occasion to much discussion,—many believing them to be of mediæval rather than of Roman origin. The words, rudely scratched in Roman capitals, are as follow:—

R O T A S
O P E R A
T E N E T
A R E P O
S A T O R

It will be seen that these words read either horizontally or perpendicularly, up and down, form the same words. Now it is not a little remarkable that these same words, so arranged, are recorded as having been found in a Cornish pedler's pack of charms so lately as 1873, and Mr. Birch, of the British Museum, has found them in a M.S. of the 17th century, containing magical signs and charms against wounds and bruises, inscribed beneath with the words *contra hostes et inimicos.* Yet strange to say, there seems to be no doubt that the words so scrawled on the piece of wall-plaister in the Museum at Cirencester are in good Roman lettering of what is known as the "Rustic" character, of the first or second century of the

Christian era. They have thus been handed down, probably through the monks, and have subsisted as a magical formula from the Roman down to the present time.

Some of the party went to see the gravels at the Barton pits, but found them so full of water that the gravels which they went to examine were not within reach. In Vol. V., p. 275, of the "Proceedings of the Cotteswold Club," there is a paper by Mr. Thistelton Dyer on Flint Flakes found at the Barton pits under the turf which immediately overlies the gravel. One of these flint implements, with the authentication of the British Museum attached, was shown in one of the cases at the Museum, but its artificial character was much doubted by some.

Time did not admit of a very prolonged delay at the Museum, and the party, filling two brakes, proceeded along the Churn Valley in the direction of North Cerney. By the way, two halts were made, at Stratton to examine a quarry in the "Forest Marble," and at Baunton to inspect a section in the "Great Oolite," which yielded to Mr. Witchell some pretty specimens of "*Hyboclypus agariciformis*," and a large form of "*Lucina*." At Perrotsbrook the party left their carriages, and under the guidance of Mr. G. B. Witts, proceeded to examine some very extensive lines of entrenchment, which are noticed by the late Mr. G. F. Playne in his paper on "The Ancient Camps of Gloucestershire," in Vol. VI. of the "Transactions of the Cotteswold Club." These lines have been traced by Mr. Playne for the distance of a mile and a half; they can hardly, therefore, have been constructed solely for military purposes, but rather as a place of security for an entire tribe with its families and cattle.

About a mile beyond Perrotsbrook is North Cerney, which village was the limit of the excursion. The church proved to be a most interesting structure, though a thorough scraping which it had recently undergone had removed all the rust of antiquity from the interior. It is in its origin a Norman Church, dating from the early part of the 12th century. The chancel arch and the northern doorway are all that now remain

of the original church, though Norman work is still traceable in buttresses and bits of string-courses. The upper part of the tower is very noticeable; it contains double windows of a transitional Norman character, under a sort of projecting hood-mould with corbels. The ashlar of this part is good, and contrasts favourably with the rubbly masonry of the earlier portion below. Within the church are the remains of stained glass of fine character in mutilated figures of saints and martyrs, and a crucifixion with figures of the Virgin and St. John, shaming by their quiet harmonies a hideous modern insertion in garish and discordant colours.

Having completed their survey of the church, the party re-entered their carriages and drove to the lodge in Lord Bathurst's Park, known as "King Alfred's Hall," a favourite rendezvous for pic-nic parties in the summer months. Here they found—together with a fire blazing in the hearth, which was not unwelcome, for the day had proved cold and showery—a repast, which though it could not be called sumptuous, was very welcome.

After dinner, Mr. J. H. Elwes called the attention of the Club to a subject which he considered to be of great importance, namely, the collection of information respecting the effect upon vegetation in this country, of the three preceding winters and of the summer of 1879; a subject which at the instigation of Mr. Elwes, has been taken up by the Royal Horticultural Society of London. It is not difficult to appreciate the importance of such an enquiry, and its bearing upon the future of horticulture and arboriculture in England. To nurserymen, especially, the experience thus gained and registered must be of the highest value, they having lost property to the value of many thousands of pounds, especially amongst roses and conifers. Mr. Elwes proposed, with the consent of the Club, to draw up a report relating especially to Gloucestershire, and to publish it in the Transactions of the Club. Mr. Elwes next called attention to the question of drawing up and publishing a list of the birds of the county, having reference not only to the occurrence of rare stragglers, but

to the distribution and breeding of the commoner sorts. He thought the time was come when this should be done. The British Ornithologists' Union had appointed a committee to revise the nomenclature of British birds, and the list they had drawn up would shortly be published. He would be very happy, taking this as a foundation, to collect and edit as complete a list as possible of the birds of the county, in the preparation of which he invited assistance from all in Gloucestershire who are interested in the subject.

Dr. Paine referred to the importance of a Meteorological Register for the county, and advocated the annual collection and publication of facts under that head.

Mr. Taunton, C.E., then offered a few remarks introductory to a paper which he proposes to contribute to the Transactions of the Club on the "Valley of the Churn, and the Borings at the Barton." It would appear from Mr. Taunton's experiments, that the River Churn in its course over the Oolite parts with a large proportion of its waters, which making their way through fissures in the substratum, form an underground stream not greatly inferior in volume to that which passes above ground. The borings at the Barton have been directed to the tapping of this subterranean source, which was reached at a depth of 93 feet, when the water sprung to the surface with considerable force, yielding with a 3½ inch bore about 1800 gallons per hour. At Mr. Bowly's brewery, with a larger bore, and at a somewhat greater depth, water was obtained yielding a flow of 3000 gallons per hour.

With the termination of Mr. Taunton's address, the proceedings of the day came to a conclusion, and the party separated.

The Second Field Meeting of the season was held on June 21st. I was debarred by illness from being present at this very interesting meeting, and am indebted to our Secretary for a report of the proceedings of the day.

The Club on this occasion availed itself of the recent opening of the new line of rail from Cheltenham to Oxford,

to examine the section opened up between Andoversford and Bourton-on-the-Water. Starting from the

ANDOVERSFORD STATION

the party proceeded to examine the geological sections exposed in the railway cuttings between Andoversford and Notgrove. There are several cuttings varying from 15 to 36 feet in depth: they pass through Inferior Oolite, Fuller's Earth, Stonesfield Slate, and Great Oolite, and present a sequence of strata without comparison in the Cotteswolds. The sections commence with the beds which cap Leckhampton Hill, and comprise all the succeeding strata of the several formations before mentioned. Each formation was identified by its fossils or its petrological structure and position. The Gryphite bed, with "*Gryphœa sublobata*," and the "Trigonia" grit with casts of "*Trigonia signata*," were seen in position; but the succeeding "Clypeus" beds proved from their wealth of fossils the most attractive—"*Clypeus Plotii*" (Klein) studded the face of the section with its bun-like form: the broken stone used for ballasting the railway contained scores of specimens, though perfect examples were rare. The "Clypeus" grits in the deep cutting west of Notgrove are about 20 feet thick, and contain in addition to "*C. Plotii*" the usual fossils of the bed, amongst which "*Pholodomya Heraulti*" (Ag.;) "*Homomya gibbosa*" (Sow.;) and "*Myacites subelongatus*" (Ag.;) were amongst the most abundant. The "Fuller's Earth," though greatly diminished in thickness, was seen with the underlying and overlying formations in the same section. This is the only instance of the kind in the Cotteswolds; it was, therefore, examined with great interest. The hard bands which characterise the formation were noticed, but were found to be more than usually sterile. The small oyster "*Ostrea acuminata*" (Sow.) of which these bands are frequently composed, was rather rare, but "*Ostrea Sowerbyi*" was in some of the layers very abundant. The "Stonesfield Slate" was of the usual character: in certain beds it was sandy and fissile, in others hard and full of shelly detritus and small

oysters. The "Great Oolite" consisted of rough rocks, and was very different from the Shelly Oolite of Minchinhampton: only one of the shelly beds was found, and that one contained only very small shells and shelly detritus. At the Notgrove Station the "Oolite Marl" and the "Freestone" beds appear in the section, but these for want of time were not examined.

The next point on the programme, was the barrow near Notgrove, referred to by Mr. Witts at the Annual Meeting of the Club. It is a long barrow or chambered tumulus, of the kind well known on the Cotteswolds, and agreeing in most of its details with those of Uley and Nympsfield. Like them it had lost most of the covering stones of the chambers, but more than 20 of the upright slabs were in place, and were well preserved. It was 140 feet long by 78 feet broad, and its greatest height at the south-east end from 10 to 12 feet. It had evidently been enclosed by a well-built wall, which was well exposed, as also the fine dry walling of the central passage. This passage was 27 feet long (that at Uley is 24,) and varied in width from 4 ft. 3 in. to 5 feet. One chamber had not been much disturbed, and in it were found beneath a flat stone, the remains of two skeletons in a crouching posture, some bones and teeth of a quadruped (perhaps a deer,) 30 pieces of pottery (very early British,) one well-formed flint arrow head, and a curious bead of Kimmeridge Shale, already referred to as similar to one described by Greenwell and Rolleston as found at Eyford, in this county.

At Notgrove the party were received by the Rector, the Rev. D. F. Vigors, who conducted them over the Church, and explained the various points of interest.

At Bourton the Club was met by Mr. Moore, a gentleman distinguished in the neighbourhood as an accomplished antiquary, who led the way to the site of a Roman Villa near the Foss-way, close to the entrance to the village. Here Mr. Witts had men at work who had exposed some of the foundations, and on a cross cut being made through one of the walls, their search was rewarded by the discovery of a number of Roman coins, and a well preserved portion of the base of a column

about nine inches in diameter. Mr. Moore then read a very interesting paper on the building then under examination, and traced portions of the walls into a field on the further side of the railway embankment.

After a hasty visit to the residence of Mr. Moore, with scant time to glance at his interesting collection of coins and other Roman antiquities, the party made their way to Salmonsbury Camp, conducted by Mr. Moore, Mr. Witts, and the Rev. E. F. Witts. This camp encloses a very large area, the two sides being upwards of 550 yards long, extending in one direction to the river Windrush. At various points of the outer boundary the earth had been removed and the walling laid bare. There can be little doubt, judging by its construction, that this dry walling is of early British and pre-Roman work, though doubtless the British entrenchment was occupied by the Romans, in illustration of which there was found within the area of the entrenchment a bundle of curious unfinished iron sword blades, similar to those discovered at Hod Hill, in Dorsetshire, and referred to in Wright's "Celt Roman and Saxon." Several of these were seen in the collection of Mr. Moore, and examples should, if possible, be secured for the County Museum.

As regards the word "Salmonsbury," Mr. Witts thinks there can be little doubt of its pre-Roman construction. He is my authority for stating that the first recorded mention of it is in Kemble's "Codex Diplomaticus," Charter 137, Offa, A.D. 779.

The Third Field Meeting was held on Tuesday, 12th July, at

THE BLACK HORSE INN, BIRDLIP,

than which there are few more beautiful spots in the Cotteswolds. The day was all that could be desired—cloudy, with a pleasant breeze and a warm sun—and proved highly favourable for the execution of the prescribed programme, which comprised an examination of an extensive system of earth-works (not hitherto noticed) at Cooper's Hill, and a visit to the West Tump barrow in Cranham woods, which had yielded such interesting results to the investigations of Mr. Witts and Professor Rolleston.

At the appointed hour of noon, the Club mustered at the "Black Horse," and proceeded thence, under the guidance of Mr. Witts, in brakes and wagonettes, to examine the earth-works at Cooper's Hill. These are upon a scale so extensive, and enclose so large an area, that it seems strange they should hitherto have escaped notice. Even the observant eye of Mr. G. F. Playne, whose paper on "the Camps of Gloucestershire," in "the Proceedings of the Club," is a standing monument of his patient research and perseverance, failed to detect them, although he notices the remains of an entrenchment at the point of Cooper's Hill. It remained for Mr. Witts to discover this system of entrenchments, which from its extent is one of the most important in the Cotteswolds. The fact that these earth-works are in all their most salient points concealed by woodland, is doubtless the cause that they have hitherto been overlooked by antiquaries.

Cooper's Hill is one of the most prominent of the many capes and headlands which project from the coast-like range of the Cotteswolds into the vale of Gloucester. At its salient angle, as has been already noticed, there exist the remains of an earth-work which may possibly have been used as a point of observation by the Romans, who seem to have had look-out stations on most of these commanding promontories; but the earth-works to which attention has now to be directed have no connection with the Roman conquerors, nor with the Danes, Saxons, or Northmen who succeeded them, but date from a period altogether antecedent to all these successive waves of invasion. They may be described as two concentric lines of rampart and foss, extending from Prinknash on the west, to a point in the Buckholt wood on the east, a distance of nearly two miles, and resting either flank on the precipitous face of Cooper's Hill, which thus forms a natural fortification, the gorge of which is defended by a double line of vallation. The area enclosed within these boundaries is about 200 acres in extent—much too large, as it would seem, for a military work, but well adapted for an "*oppidum*," which would serve to protect the settlement of an entire tribe with its flocks, herds, and cultivated ground. Further to strengthen this

extensive line of ramparts, there is in rear thereof, and about the centre, a small irregular fort, less than an acre in extent, which was doubtless used as a "*Place d'armes.*" This, like the rest, has to be sought in thick woodland, which is so intricate, that even with the aid of Mr. Witts and the Ordnance Map, it was not easy to determine the relation of the fortification to the general disposition of the ground. The inner line of rampart, where exposed, has been much levelled by cultivation, but it is well seen on the eastern flank above Prinknash.

The party made their way to the May-pole on Cooper's Hill, and for a short time were permitted to enjoy the glorious prospect from that point of vantage. From thence the party proceeded to the West Tump Barrow, about a mile distant, where Mr. Witts had had the dry walling exposed, and the excavations laid open for examination. This tumulus was the subject of one of the last letters written by the lamented Professor Rolleston, who, from the first, took a most lively interest in it, and pronounced it to be one of the oldest type of long barrows yet discovered, being much older than the chambered barrows of Uley, Nympsfield, and Notgrove. This barrow is of the "horned" form, 149 feet in extreme length and 76 at its greatest width. It is carefully constructed of hand-packed stones, and is surrounded by dry walling, very neatly put together. The true entrance was not found at the "horned" extremity, where it would naturally be looked for, but at a distance of 82 feet from the southern horn, a break was found in the exterior line of walling, which proved to be the entrance to a sepulchral chamber. Here great quantities of human bones were found in a confused mass, but the farther the excavators penetrated into the interior, the more perfect became the skeletons, till at length, at a distance of 24 feet from the outer wall, the trench terminated in a sort of semi-circle, around the extremity of which were five flat stones, on which, sitting in a contracted position, was the skeleton of a young woman, with the remains of a baby in close proximity. At this point the trench came to an end, and there were no further signs of bones in any direction. Professor Rolleston

was of opinion that it was in honour of this last body that this great cairn of stones had been piled up—who shall say how many thousands of years ago! All the skulls found were of the long-headed type; they have been properly cared for, and it is hoped that some of them, carefully set up, will find a place in the Gloucester Museum.

Mr. Witts read a paper on "The Barrow," and was at great pains to explain to those present all the points of interest in connection with this most interesting "find," the discovery of which is entirely due to his acuteness and energy.

The next move was to the garden of Mrs. Beach, at Cranham Lodge, where the party were entertained at tea. On their return journey to the "Black Horse," attention was directed to some extensive quarries in which the building free-stone is excavated by means of galleries, extending many hundreds of yards underground. Candles were provided, but those who ventured in found these subterranean passages cold, damp and muddy, and soon returned to the open air. Meantime a select few went on to the quarries at Birdlip Hill to view the "Pea Grit." Here Mr. Lucy called attention to the inclination of the strata from below the village to the point whereon they were standing, showing that a large amount of denudation had taken place, whereby the whole of the Freestone, Oolite Marl, Rag Stones, Fuller's Earth, and Great Oolite, that once covered up the Pea Grit had been swept away.

After dinner at the "Black Horse," the President proposed amid cheers, that the thanks of the Society should be given to Mr. G. B. Witts for his valuable services in the promotion of antiquarian discovery in our county, to which he had made so many important contributions. Mr. Witts, in reply, made reference to the importance of protecting and preserving from further loss and demolition those relics of past ages which are still left to us, but which are every day in danger from the ignorance of some and the indifference of others. In particular, he drew attention to two round barrows in the parish of Duntisbourn Abbotts, which are marked on the Ordnance Map, and are described as two of the finest in the County, which

were then in process of demolition for road repairs. It was suggested that measures should be taken to protect them. This I am informed has since been done, and some excavations made under the direction of Mr. Witts.

The Fourth Field Meeting was held at

BATH

by invitation from Handel Cossham, F.G.S., on Tuesday, 16th August. But few parts of England can vie with the neighbourhood of Bath in features of natural beauty. The bold escarpment of the Cotteswolds, and the richly-wooded undulations of the lower slopes, combine with prospects of illimitable beauty to form a whole most attractive to the lover of the picturesque, while to the geologist the variety and complexity of the geologic conditions present a succession of problems of the most interesting character.

The Club, which even in the wettest seasons has been singularly fortunate in its weather, was on this occasion exposed to a reverse, which sadly marred the enjoyment of the excursion, for it rained without intermission the whole day, and the excursionists packed in open carriages were exposed to all the inconveniences entailed by such a condition of things. But their enthusiasm was equal to the occasion, and nothing damped by the untoward influence of "Jupiter Pluvius," the party proceeded to carry out its programme.

At Bitton Station the Wills-bridge "fault" exposed on the railway was visited by some of the party. At this spot occurs one of the most remarkable "faults" in the Bristol district, and at the same time one of the simplest to understand. A vertical displacement of at least 1000 feet has taken place, by which the "Pennant" or middle zone of the coal-basin has been brought up to the level of the "rhætic" beds at the base of the lias; and this by a movement so gradual that it has scarcely shifted the ends of the beds on either side of the "fault." Prior to the turfing over of the "rhætic" and "lower lias" section (the particulars of which are luckily

preserved through accurate measurements) it was a most remarkable section.

Their next visit was to the Church at Bitton, a structure of considerable interest, the peculiarities of which were explained by the Rector, the Rev. Mr. Ellacombe. It is a single-aisle church of considerable length and height, with remains of Norman work about it. It has undergone alterations at various periods, including a late restoration, in which objection might be taken to some innovations, but the general effect is good. A north chantry, the date of which is known (1299,) is a fine example of early "decorated" work, and in the chancel the beautiful sedilia, figured by Lysons in his "Gloucestershire Antiquities," are well worthy of notice; but perhaps the most striking feature is the tower, which for elegance of form and beauty of proportion cannot be surpassed. It is well seen from the garden of the rectory, which garden is in itself worthy of a visit, being well known to horticulturalists for its collection of rare plants and shrubs, for the due observation of which very different weather was needed to that which prevailed on the occasion in question.

The next visit was to two small but important outcrops of carboniferous limestone, a little north of Bush Farm, and south of the Wick Rocks. These patches have much significance in reading the physical structure of the district, as tending to show the precise limits of the eastern side of the coal-basin, and the most southerly exposed extension of the carboniferous limestone between Chipping Sodbury and Wells, on the eastern flank of the Mendip Hills. These patches are exposed both through the agency of denudation and the continued influence of the "fault" from Wick. Mr. Etheridge here briefly described the conditions under which these bosses occurred, as part of the main and continuous belt of limestone along the eastern side of the northern and southern coal-fields. The limestone beds at these two outcrops are extremely fossiliferous, and dip to the south-east. This direction, if normal, or not reversed by any "fault," would tend to show the possibility of a still more easterly coal-tract, further east than the known

limits of the basin; and when we know that at Burford, in Oxfordshire, coal-measures with characteristic fossils have been determined at a depth of 1200 feet, this view must not be overlooked when the question of the extension of other coal-fields east of the Bristol basin comes to be considered. This and other questions bearing upon the immediate area were touched upon by Mr. Etheridge.

The party next proceeded to mount the heights of Lansdown, where it had been the intention of Mr. Cossham, who had prepared a memoir on the subject, to describe the general features of the fight which took place on that ground between the forces of the King and those of the Parliament, on the 5th of July, 1643, in which engagement the gallant Sir Bevil Grenville was slain; whose monument, raised on the spot where he fell, was dimly visible through the veil of descending rain.

The broad physical features of the surrounding country would have been explained by Mr. Etheridge from Lansdown hill, had weather permitted, for probably no spot within the Bath area equals this elevated plateau, as a point from whence to generalise upon the structure and geologic history of the grand panorama spread out in all directions, especially that which embraces the entire range of the extensive coal-field from north to south—from Tortworth to the Mendip Hills. No area in England exhibits such instructive evidence of denudation under every possible condition; and to the student of stratigraphical geology, especially in the Jurassic division of the secondary rocks, the Bath area has no equal. The only drawback to the pleasure in store for the Cotteswoldians in their anticipated study of the area, was the weather, and if the day could be called, in geologic parlance, "*a period*," most assuredly it was a "*Pluvial*" one. But there was "Balm in Gilead," and though the feast of geologic lore was witheld, that of substantial creature comforts was there in abundance to satisfy appetites not a little sharpened by exposure to the chilly vapours without, for upon arrival at the "Grand Stand," on the race-course, they found that their hospitable entertainer, Mr. Cossham, had

provided for them a splendid banquet, where flowers and fruits, intermingled with more solid dainties, invited the hungry wayfarers to partake. After dinner a few toasts helped to pass the time, after which the party broke up and dispersed.

This was the last occasion upon which the Club met their old and valued associate, Mr. Charles Moore, whose lamented death has already been chronicled in the earlier part of this address.

The First Winter Meeting of the Club was held at the Lecture Theatre of the

SCIENCE SCHOOL IN GLOUCESTER

on Thursday, 19th of January in the present year, when a paper was read by Mr. E. Witchell, F.G.S., on "The Pisolite and Basement Beds of the Inferior Oolite of Gloucestershire." The "Pisolite," or "Pea Grit," is peculiar to the Cotteswolds. It consists of a deposit of flat or round grains, varying in size from the eighth to the third of an inch, the flat shape being the most prevalent. The bed is about 30 feet thick at Cleeve hill; it becomes thinner at Birdlip, and thins out south-west of Stroud. From a careful examination of the pisolites, Mr. Witchell was of opinion that their concretionary structure was due to the aggregation of layers of muddy detritus round a fragmentary nucleus of portions of shell or coral. Mr. Witchell traced the "Pisolite" beds from Cleeve to Selsley hill, and from Haresfield hill to Chalford, an area of 140 square miles. He said that the "Pisolite" had been generally regarded by Cotteswold geologists as the basement of the Inferior Oolite, and as the introduction of the Oolitic structure. This he showed was not the case; and he detailed numerous sections from Cleeve hill along the escarpment to Uley Bury, and others taken near Stroud, to show that while in the Cheltenham area the basement beds are thin and unimportant, they are gradually developed towards the south-west, and consist of beds of Oolitic limestone and freestone, some of which are of greater thickness than in any other Oolitic rocks of the Cotteswold series. Mr. Witchell

considered that these beds had been somewhat overlooked, mainly because our Gloucestershire geologists had been led to regard as typical the section at Leckhampton, which by reason of the meagre development of the beds in that section it was not.

In the discussion which followed the reading of this paper, Dr. WRIGHT said he quite agreed with everything in it, but that it stopped short of the most interesting point. Mr. WITCHELL had not given the origin of the "Pisolite." As regards the basement beds, he was surprised that Mr. WITCHELL had not referred to his paper published in the transactions of the Geological Society upwards of twenty years ago. He had measured the basement beds thirty years ago, and had given the results in that paper. The beds were not at all new to him.

Mr. WITCHELL, in reply, expressed his regret that he had not read Dr. WRIGHT's paper. He had, however, seen a reference made to it by Professor HULL, in his Memoir of the Geological Survey, in which the Professor stated, upon the authority of the Doctor's paper, that the "Pea Grit" was the basement of the Inferior Oolite and the introduction of the Oolitic structure. Mr. WITCHELL therefore concluded that Mr. HULL, in his paper, did not refer to the great thickness of the true basement beds which underlie the "Pea Grit," and rest upon the "Cephalopoda bed" of the Upper Lias, a thickness of more than 30 feet.

It was, after some discussion, agreed that reference should be made to the paper published by Dr. WRIGHT.

Mr. WITCHELL next exhibited some bones from the "angular gravel" bed on the slope of Painswick hill, which he regarded as an important fact. They had been found at a considerable depth, and this he believed to be the first example of animal remains from the "angular gravel." The nature of the bones was not given.

The Second Winter Meeting was held on the afternoon of Monday, the 27th of February, under the presidency of Dr. WRIGHT, F.R.S.

A short paper was first read by the Rev. E. CORNFORD, in which was quoted a passage from "Chron. Abb. de Evesham,

p. 9, Rolls Edition," giving a clue to the origin of the name of Evesham. It recorded that one Ecgwin, a "humble bishop of Wicci," who lived in the reign of Ethelred, was frequently favored by visions, and having, he writes, "an ardent desire in my mind if God would prosper my longings, to build a place to the praise of our Lord, and the blessed Virgin Mary, and all the elect of God, as well as for my own eternal reward before I depart from this mutable life," besought the King to bestow Hethomme upon him, and the King granted his request. At this place the Virgin Mary had appeared to a herdsman named Eoves. Subsequently she also appeared to Ecgwin, and he immediately purified the spot and built a monastery there; and in consequence of the sanctity of Eoves he named the place Eovesham. This extract was regarded by the writer as throwing light upon two curious pictures, the mystical subjects of which sorely puzzled the Archæologists on the occasion of their visit to the old Manor House at Little Washbourn, in August, 1879, in which a peasant was represented in the dress of the period, with another in the habiliments of an abbot or other such ecclesiastic; and in each picture, the narrator believed, was a representation of the Virgin.

Dr. F. Cook, of Cheltenham, then read a short paper on a skeleton and certain remains found therewith, two years ago, in a quarry a few hundred yards to the south of the Roman camp on Crickley Hill. The skeleton was that of an adult, and from the character of the bones and the objects of female ornament which accompanied it, was judged to be that of a female. Within a few days another skeleton had been discovered in the same quarry, which from the objects found with it, was believed to be that of a male. The skeleton of the first-named individual was in a perfect state of preservation, not a bone being wanting, whereas those of the latter, from being saturated with moisture, would scarcely bear the handling. The great difference in the condition of each was the depth from the surface at which the bodies respectively lay, the lady having five feet of Oolite above her, while the male lay within

thirty inches of the surface. Both skeletons lay with their heads due east. In the case of the female, a kind of cist was formed of narrow flat stones around the body; that of the male was merely covered with rubble. An iron sword, much corroded, lay on the left of the male skeleton; a bronze circlet and two bronze plates were found among the bones of the skull, which the weight of the stones had crushed: the sword was seventeen inches in length, four in the handle, and thirteen in the blade, two inches wide in its broadest part, and tapering to a somewhat abrupt point: its weight was sixteen ounces, and it bore on the surface the marks of some textile fabric with which it had lain in contact. The circlet of bronze, 22 inches round, had in some parts the appearance of having been gilt, like that on the mirror of the lady, but Dr. Cook had been informed by Mr. Bellows that this appearance had been produced by the application of lacquer to the polished bronze. The two bronze scales of concentric form, each seven inches long, had a small dotted pattern on their outer edges, and in the centre was a hole in which had been inserted an iron fastening to attach them to wood or leather. In looking over the bones, Dr. Cook found no teeth among the *débris*, but on examining a portion of the lower jaw, it became apparent that the individual had parted with his teeth long before his decease, and that the remains were those of a very old man. An examination of the thigh bone showed that it had belonged to a man of small stature. Dr. Cook showed the form of Roman swords as figured in Dr. Smith's "Roman Antiquities," from which he concluded that the remains were those of a legionary soldier of the Roman Empire. In conclusion, Dr. Cook exhibited several relics, one being a sacrificial knife, and several smaller instruments, of the use of which he was doubtful, and invited information.

In the discussion which followed, Dr. Wright took exception to the theory that the skeleton first discovered was that of a Roman, and said it was not at all likely to be that of a female. The remarkable angle of the jaw, and the manner in which the teeth were ground down, indicated a powerful masculine

individual, and he expressed an opinion that it was a British skull of the pre-historic period.

Mr. E. Wethered, F.G.S., then read a paper on "A Section of Strata exposed in a Railway cutting at Morse, near Drybrook." The Bristol, Somersetshire, and Forest of Dean Coal-fields, are, he said, to be regarded as outliers of the great South Wales coal-basin, and the disconnection having been effected by the up-lifting of the older rocks into an anticlinal curve, which has since been removed by denudation, while the patch of Coal-Measures in the Forest of Dean was preserved by their lying in the trough of a synclinal curve. The severance between the Coal-fields of Bristol and Somersetshire was effected in the same way. By reference to the Geological Survey Map of England and Wales, the Forest of Dean Coal-basin is shown surrounded by belts of "Millstone Grit" and "Carboniferous Limestone." There is however a considerable thinning out in thickness: the total thickness of the Limestone in the Avon section at Clifton is 2,900 feet, while at Perlieu the thickness is 1,102 feet. In South Wales the thickness of the same deposit, according to Mr. Foster Brown, is from 700 to 1,000 feet. The "Millstone Grit" at Bristol may be taken to be, on a fair average, about 1,000 feet thick, but at Perlieu it is represented by a thickness of about 41 feet, and in South Wales of about 200 feet. The "Carboniferous Limestone" rests upon the "Old Red Conglomerate," and the passage beds between these two formations are exceptionally well developed in the road from Ross to Drybrook, in what is known as "The Deep Cutting." The "Old Red Conglomerate" is composed of veined quartz pebbles, embedded in an arenaceous ferruginous matrix. The section to which he specially drew attention has been exposed at Morse, in making the branch line of railway to Mitcheldean. The Limestone is not exposed in the cutting, nor is the total thickness of the Sandstone to be ascertained at this point. The bed consists of well-rounded grains of quartz and a little felspar. The quartz grains are many of them scratched; they average about ·01 of an inch in diameter, and are cemented together by Kaolin, derived probably from the

decomposition of felspar. The quartz grains also possess oblong cavities, containing a liquid. When first he saw this bed Mr. WETHERED doubted its being "Millstone Grit," as the physical features were different from any which he had seen before, and very different from the same formation as exposed around Bristol. The matter was decided on a second visit to Drybrook, when he procured a "*Lepidodendron*" from a quarry about half a mile off, opened on the same bed, which, however, was not capped by the beds which overlie it in the Morse section. A third visit to Drybrook left no doubt on the subject. He came across another quarry to the left of Euroclydon: at the top was the mottled Sandstone bed, and below that came a yellow Sandstone; below that came a yellow variegated Sandstone of a more compact structure, the grains of which were less rounded, and inclined rather to partake of the features referred to as characteristic of the grit from Bristol and around Sheffield. Passing from the "Millstone Grit" in the Morse section, we find resting upon it a bed of rose-coloured Sandstone, eight inches thick, composed of well-rounded grains of quartz, averaging ·050 of an inch in diameter, with decomposing felspar and mica. The dip of this bed is 15°; taking therefore the dip of the "Millstone Grit" as 40°, we have decided unconformability. Upon the bed of rose-coloured Sandstone rests a bed composed of large quartzitic and trap rock pebbles; mixed with these are smaller fragments of quartz, which are however of a different character to the larger pebbles. Placed side by side with the veined quartz of the "Old Red Conglomerate," it is difficult to distinguish one from the other. The large quartz pebbles seem to have been derived from the denudation of "Caradoc Sandstone" rock, similar to the beds described by Sir RODERICK MURCHISON as occurring at the Lower Lickey Hills, in Worcestershire. Mr. WETHERED said that he was not aware of the occurrence in the Forest of Dean of another bed of pebbles similar to that at Morse. Had it been contemporaneous with the "Millstone Grit," it was not likely that it would be confined to the one locality of Drybrook; it therefore appeared to him that we must either regard the "Conglomerate,"

and the thin bed of Sandstone on which it rests, as belonging to a more recent formation, or to some local feature, such as the old river bed, referred to by Sir CHARLES LYELL as running through the Forest of Dean. Reviewing the evidence, Mr. WETHERED said he was quite satisfied that the lower bed of Sandstone is the "Millstone Grit," though the characters it developes are peculiar, but he was disposed to regard the beds above as an outlier of the Trias; the pebble beds being identical with those at Budleigh Salterton, and those which follow as the lower beds of the "Keuper."

Mr. LUCY, in opening the discussion, said he could not agree with Mr. WETHERED that this bed was the effect of unconformability. He believed that the beds above and below were "Millstone Grit," and that this was an intercalated bed. The beds were all in complete order, with the exception of this, and it was necessary to account for such a complete displacement as that of the "New Red" being thrust up between these two beds. He hoped the Club would visit the section as being one of the most interesting in England.

Dr. WRIGHT thought that the dip, showing a difference of between 15° and 40° of angle, was a strong mark of unconformability, and would require careful investigation before they decided that Mr. WETHERED's version was not a correct one. It suggested a great change of conditions and a great lapse of time between the formations, and it was most important that the point should be well worked out.

The last Winter Meeting of the Club was held at the Lecture Theatre of the

SCHOOL OF SCIENCE AND ART, AT GLOUCESTER,

on Tuesday, the 28th of March in the present year, when a paper was read by Mr. HANDEL COSSHAM, F.G.S., on "The Cannington Park Limestone."

About four miles from Bridgewater, in Somersetshire, is a boss of highly crystalline Limestone, which for 40 years has occupied a doubtful geological position, having been regarded by some geologists as belonging to the Ilfracombe group of the

Devonian series, while by others it has been classed as a southern extension of the carboniferous limestones of the Mendips. The difference between these two opposite views involves an important economical problem, for if the latter view be the correct one, viz., that these limestones are of carboniferous age, it may be regarded as in the highest degree probable that coal within a workable distance exists in the trough of the "synclinal" between Cannington and the Mendips. With a view to the solution of this problem, Mr. Cossham, in company with R. Etheridge, F.R.S., President of the Geological Society, and your President, visited the locality in the autumn of last year, and were successful in finding such fossil evidence as satisfied them of the carboniferous character of the limestone. The difficulty of assigning to this rock its true position has arisen from its highly crystalline structure, and from the almost total absence of organic remains, which when found, are so crushed and fragmentary as to render their determination in the highest degree difficult. Hence it arises that so many eminent geologists have differed in their diagnosis of the true nature and position of the Cannington Limestone. Mr. Etheridge, one of the most competent observers, had, in his paper on "The Physical Structure of West Somerset and North Devon," given it as his opinion that the limestone in question was a Devonian outlier, and though later observers had come to a different conclusion, he had seen no cause to change his opinions. It would seem that his attention had not been drawn to a paper by Mr. Tawney, F.G.S., read before the Bristol Naturalists' Club in November, 1875, in which, after summing up all the evidence upon the subject, together with observations made by himself on the spot, Mr. Tawney came to the conclusion that in his opinion the Cannington Limestone had been proved to be carboniferous. In like ignorance of Mr. Tawney's paper, Mr. Cossham had drawn up a notice of the facts, and of the conclusions from those facts, independently arrived at by himself and his companions, by which they had been led to recognise the carboniferous character of the limestones in question; and it was not until after the completion

of his paper that Mr. Cossham was made aware that the question had already been determined by Mr. Tawney. Under these circumstances, Mr. Cossham's observations could no longer be regarded as throwing new and original light upon the question, but merely as confirmatory of a proposition already established. Nevertheless, the work has its value as that of independent observers, and notably as having effected the conversion of Mr. Etheridge, who when convinced of his previous error, at once with the candour of a lover of truth retracted his previously recorded opinions, and recognised the carboniferous value of the Cannington Limestones with all the important deductions resulting therefrom.

Some observations were made by Rev. Mr. Winwood, of Bath, who accompanied Mr. Tawney on his visit to Cannington, and by Dr. Wright, on the evidence of previous writers on the subject.

Mr. Witchell then made some observations on a paper recently read by him on "The Basement Beds of the Inferior Oolite." These had reference mainly to some remarks made by Dr. Wright, in which he claimed, in a paper published in the Quarterly Journal of the Geological Society so far back as 1856, to have already distinguished the limestones below the "Pea Grit" proper, which in their greater development in the Stroud district were regarded by Mr. Witchell as having been hitherto overlooked. This led to a somewhat animated discussion, in which the Doctor energetically maintained his position.

The meeting was addressed by Mr. Lucy, Mr. Longe, and Mr. Winwood, with a general concurrence of opinion that having regard to the different facias presented by the same beds in different localities of the Cotteswolds, the independent work done by Mr. Witchell must be recognised as a substantial contribution to our knowledge of the basement beds in question, and as a valuable extension to the Doctor's earlier sections, the truth of which were not at all thereby called in question.

With this meeting the work of the Club for the season terminated, and so I take leave to close this address, thanking you all for the kind support which I have uniformly, and now for so many years, received from the members of the Cotteswold Club.

PROCEEDINGS

OF THE

Cotteswold Naturalists' FIELD CLUB

For 1883—1884

President

SIR WILLIAM V. GUISE, BART., F.L.S., F.G.S.

Vice-Presidents

T. B. LL. BAKER, ESQ., F.S.S.

THOMAS WRIGHT, M.D., F.R.S.L. & E., F.G.S.

WILLIAM C. LUCY, F.G.S.

Honorary Secretary

W. H. PAINE, M.D., F.G.S., F.R. MET. SOC.

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JOHN BELLOWS, GLOUCESTER.

PERMANENT PHOTO. BY WILLIAM GILLARD. GLOUCESTER

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F.R.C.P. Lond: F.G.S.
Hon. Secretary Cotteswold
Naturalists Field Club

Address to the Cotteswold Naturalists' Field Club, delivered at Gloucester, on the 24th April, 1883, by the President, Sir William Vernon Guise, Bart., F.L.S., F.G.S.

Gentlemen,—

In compliance with custom, I will proceed to give a summary of our proceedings at the different Meetings of the Club during the past season; but before doing so I will briefly allude to the condition and prospects of the Club, which, I am glad to say, are in all respects satisfactory. Our numbers are well maintained, and I am glad to say that we have no deaths to register amongst our Members. The Papers read at our Winter Meetings are of a character to give value to our "Transactions." Of these I would more especially refer to the Paper by Mr Wethered, on "The Drybrook Beds," which is of great value to local Geology.

Our Hon. Treasurer, Mr Witchell, has been indefatigable in his exertions to collect arrears of subscriptions, which, I regret to say, are in some instances very large. It is strange that gentlemen who receive the published "Transactions" of the Society should fail to pay their annual subscriptions for many years in succession. Our subscriptions (only 15s. a year) are not heavy, and full value is received in the annual publications of the Society. This deficit must not continue, and the Treasurer, acting under my instructions, will take such steps as are necessary to secure payment. The financial condition of the Club is, on the whole, favorable. The balance in hand last year was £30 16s. 11d., and this year it is £49 7s. 5d.

I will now proceed to the report of our proceedings at the different Field and Winter Meetings of the Club.

ANNUAL MEETING.

The Annual Meeting of the Club was held at the Bell Hotel, Gloucester, on Tuesday, 18th April, 1882, under the Presidency of Sir W. V. Guise, who read an Address, containing a review of the work done by the Club during the preceding twelve months. The election of officers for the year then took place, which resulted in the re-election of the former President, Vice-Presidents, Hon. Secretary and Treasurer. The loss by death of Mr Charles Moore, F.G.S., of Bath, and of Dr John Lycett, of Scarborough, formerly of Minchinhampton, in this county—both old and distinguished Members of the Cotteswold Club—was feelingly alluded to by the President in his Address. The Hon. Treasurer, Mr Witchell, shewed that the funds of the Club were in a good state, and would be better were all the arrears got in. Four new Members were elected, and the meets of the Club for the season were fixed.

Sir William Guise read some notes upon the appearance at Elmore of the Garganey Teal *(Querquedula circia Linn.)* According to the latest authorities, Yarrell, in his "British Birds," and Dresser, in his "Birds of Europe," the Garganey is described as a very occasional visitant to this country, and is noted as of especially rare occurrence in the west of England. Their arrival has generally been observed in the spring, on their southerly migration, though occasionally they have been seen in the autumn.

The Club dined together, as usual, at the Bell Hotel. On the motion of Dr Wright, F.R.S., it was resolved that in future there should be four Winter Meetings of the Club, to be held in the first week of the months of November, December, February and March.

The First Field Meeting of the season was held on Tuesday, May 16th, 1882. The programme for the day embraced a wide range for exploration, extending through the heart of the Dean Forest district, from

for which special facilities had been provided by the Engineer of the new line from Coleford to Monmouth, a portion of which, still incomplete, was traversed for the first time on the present occasion. The weather was all that could be desired, and, under a bright sun and a cloudless sky, the beautiful scenery through which the route lay was seen to the greatest advantage.

The first halting-place was at Coleford, where the party was transferred to carriages in waiting, and, under the pilotage of the Engineer-in-chief, were driven along the new and unfinished line of rail to Newland. This was rather an exciting journey, as the rails being only temporarily laid, the unevenness of the road made itself disagreeably felt in a series of jolts and bumps of rather a bone-dislocating character. After travelling in this way for a quarter of an hour or so, the train came to a stand-still, and the passengers were transferred to trucks with seats nailed across, in which primitive conveyances, by means of horse-traction, they passed through a tunnel in course of construction, which, though possibly instructive as a lesson in engineering, proved to be anything but an agreeable process, the drip from above, and the splashing of the horse below, leaving unmistakeable traces on the hats and coats of the passengers. This passed through, a short walk brought the party to Newland, where its fine Church and the interesting monuments both within and without, deserved a much longer study than the time at their disposal would allow. Here Mrs Oakley, the Clergyman's wife, had a pretty collection of Roman coins for examination, had time permitted, and refreshments were kindly offered. Returning to the carriages by a walk over the hill, and thus avoiding the tunnel, the party proceeded to Coleford, where a substantial luncheon awaited them at the principal hotel. This meal dispatched, they took train for Cinderford, enjoying a most delightful drive through the Forest; the woods ablaze with the many-coloured glories of spring foliage, the citrines and russets of which displayed

themselves in lovely contrast with the carpet of blue hyacinths which clothed the turf beneath. On arriving at Cinderford wagonettes were in waiting for the use of the party during the remainder of the day.

The next halt was made at Morse, near Drybrook, to examine a remarkable section revealed by the railway cutting on the line of rail to Mitcheldean, to which attention was first called by Mr Lucy, and which formed the subject of a Paper by Mr Wethered, read at the last Winter Meeting of the Club. In this section a remarkable bed is brought to light, consisting of large rolled quartzite pebbles resting upon "Millstone Grit;" and it was principally with a view to determine the position of this pebble-bed that the programme of the day had been traced. Messrs Lucy and Wethered were both agreed that the bottom-bed was "Millstone Grit," but the former Geologist held that the pebble-bed and overlying rock belonged to the same formation; whereas the latter was of opinion that they pertained to the "Keuper" or "New Red" series. Mr Lucy based his opinion upon the fact—which is indisputable—that there is no instance of the occurrence of the "New Red" within the Forest basin, while Mr Wethered pointed to the manifest unconformity of the overlying beds with the "Millstone Grit" as justifying his conclusion that they are entirely distinct. This unconformity is as between a dip of 40 degrees in the "Millstone Grit" and one of 14 degrees in the overlying bed. Mr Wethered finds the analogue to the pebble-beds in those of Budleigh-Salterton, in Devonshire, and likewise dwells on the presence of small pebbles of veined quartz believed to be derived from the "Old Red Conglomerate." The pebble-bed, thus unexpectedly brought to light, is of very limited extent, as the dip of the beds causes them to disappear at the summit of the hill, after which there is no further trace of them. The question at issue was critically examined and discussed by the Geologists present, when Dr Wright, being called upon to offer his opinion, said it was one of the most interesting bits of Geology he had ever seen, and they were deeply indebted to Mr Lucy for having

called their attention to it. Speaking as a physical Geologist, he found the unconformity so great, and indicative of so vast a lapse of time, that he could not agree with Mr Lucy's view of the contemporaneity of the beds, but was disposed to regard Mr Wethered's reading as the correct one, and that the rolled pebbles represented an old shore in the Keuper Sea.

From hence the party proceeded to Mitcheldean, where, at the George Hotel, they found tea prepared. After tea the Rev. Dr Smithe drew attention to an interesting discovery that he had lately made. He had remarked that no fewer than three German commentators, Braun, Quensted, and Oppel, had mentioned the occurrence of individuals of the sub-class "*Entomostraca*" in the top zones of the Middle Lias, at three widely separated points in Germany, all upon the same horizon. He had next found that at Churchdown the same tiny crustaceans occur in nodules, some examples of which he had sent to Professor Rupert Jones. He had since discovered the same fossil *Ostracods* in profuse numbers both at Gretton and Alderley; so that we thus have these minute organisms confined to a constant horizon, distributed over a large portion of Europe. Dr Smithe gave but a brief summary of his facts, promising to prepare a Paper on the subject, to be read at one of the Winter Meetings of the Club, with figures to illustrate the physiology of these minute crustaceans.

The Second Field Meeting took place on Thursday, 15th June, at

STROUD.

The field operations lay amongst the hills and valleys in which nestle the town of Stroud and its neighbouring villages, and along the ridge of the Cotteswolds, commanding grand prospects in all directions. Save for one or two passing showers, the day was bright and genial, and presented to the eye the varied contours of the scenery under most favourable contrasts of light and shade.

The rendezvous was at the Dudbridge Station on the Nailsworth branch of the Midland Railway, where well-appointed breaks were in waiting to convey the party. The first halt was made at Cainscross, to examine the gravel-pits there, which have at different times yielded teeth and bones of the mammoth. The exposed section shows a river-laid gravel, about 25 feet thick, containing land-shells. These gravels once extended from the Cotteswold hills to the Severn; they have since been eroded out of the main valleys, but on the flanks of the hills, and here and there in retired bays and back-waters, the beds of gravel remain to tell the tale of denudation of which they are the remaining evidences. At the point in question the lines of stratification show plainly that the gravels are the result of very slow deposition in shallow water.

At no great distance lies Moor Hall, an Elizabethan gabled manor-house, of the true Cotteswold type. But little is known of this mansion beyond the fact that in the 17th century it belonged to a family of the name of Fowler. There is a tradition that it was erected by a son of Sir Thomas More, the Chancellor of Henry VIII. There is but little note-worthy respecting it beyond the date, 1582, and an upper chamber panelled in oak. It is now a farm house.

The carriages left the valley, and proceeded by a long and toilsome ascent to climb the hill to a point known as Randwick Ash, noted as commanding one of the most extensive prospects in the entire range of the Cotteswolds, to admire which a short halt was made. The party then, under the guidance of Mr Witchell, proceeded to examine a quarry on the north side of the hill, which displays to view a fine exposure of the basement beds of the Inferior Oolite. These are the beds to which Mr Witchell made reference in his Paper read before the Club in the previous January. The section from the top downwards reads thus:—

Brown Beds	9 feet
Pisolite	3 „
Underlying Freestones	30 „

Mr Witchell holds that the "Freestones" are distinct from the "Pisolites," while Dr Wright maintains that there is no true separation between them; the lower non-fossiliferous "Freestones" he regards as representing deep sea conditions, while the overlying "Pisolites" represent a shore deposit, in which the evidences of life become abundant.

Luncheon was now partaken of under the shade of beech trees in Randwick wood, after which attention was directed to a supposed "long barrow" in the wood. This occupies a position on the brow of a ridge overlooking the vale below—just the locality usually adopted for such forms of interment, but equally well adapted for a look-out station. The finding of a couple of handfuls of human bones, with a molar tooth and some appearances of "dry walling," seem to point conclusively to its being a place of burial, and probably a "long barrow," similar to that of the "West Tump," recently explored by Mr Witts and the late Professor Rollestone.

A short half-mile from hence brought the party to Standish Park, formerly the deer-park of the Abbots of Gloucester, and still retaining the title, though the venison is no longer there. Here attention was drawn to what appeared to be a small round barrow, and to two other mounds supposed to represent a "twin barrow." These may be worthy of further exploration, more especially the single tump; the two others, from the appearance of the ground, which had evidently at some time been moved, probably in search for stone, appeared more doubtful. A pleasant walk through the Park brought the party to Haresfield hill and Beacon. While some went to explore the fine fortified enclosure which occupies the salient point of the Beacon, the Geologists applied themselves to the further examination of the "Pisolites" and underlying "Freestones" which had formed the subject of debate at Randwick hill. Continuing their way along the ridge, the party halted at the quarries at the Horsepools, to examine a coral-bed detected there by Mrs Hutton, overlying the "Oolite Marl," on to which it had been let down by the removal of the intermediate beds. The bed is very rich in species, which have been

referred by Mr R. F. Tomes* to the following:—*Thecosmilia gregaria, Isastræa tenuistriata, Thammastræa mettensis, T. Wrightii* (new species,) *Microsolina* sp., *Microsolina regularis, Montlivaltia* sp., &c. This is the same bed as that on the hill on the opposite side of the valley, at Worgan's quarry. At a point a few yards lower down the hill the lower coral-bed of the "Inferior Oolite" presents itself; it is largely quarried for road-stone, and at this point is about ten feet thick. Here Dr Wright, at the request of those present, gave an instructive address on the formation of coral reefs, and deduced from the entire change in the forms of life of the builders of the three known coral-beds of the "Inferior Oolite" that an enormous duration of time must have elapsed between the deposition of each of these beds, seeing that the vast reef of Florida, miles of which now form dry land, has been shown by Agassiz to have required at least 70,000 years for its formation, while the same industrious little builders by which it was constructed are busy at this day, continuing the work in the adjoining seas. Mr R. F. Tomes, in a Paper lately read before the Geological Society, adopts in general Dr Wright's views as to the strategraphical position of the coralligenous deposits in the "Inferior Oolite" of Gloucestershire, and gives a tabular statement of the distribution of species in the several coral-beds, pointing out that each of these has its own species, which do not pass much from one to the other.

At the invitation of Mr Lucy the party adjourned to the residence of his son, where tea was offered, and gratefully accepted. After a hasty look (it was all the time allowed) at the very beautiful garden, with its wealth of interesting plants, gathered by a former proprietor from all parts of the European Continent, and here to be seen blooming in rare perfection, the carriages were again in motion for Stroud, where, at the Imperial Hotel, the party found an excellent dinner prepared for them.

After dinner Dr Wright drew attention to the fact that, by the exertions of the Hon. Treasurer, Mr Witchell in

* See Tomes's Paper on "The Madreporia of the Cotswolds."—*Quarterly Journal Geol. Society.*

getting in the arrears, the funds of the Club were in an unusually thriving condition, and he suggested that they could not be better expended than in re-printing the earlier volumes of their "Transactions," pointing out that, owing to the important position occupied by the Club among kindred Societies, a demand had arisen for their "Transactions," of which complete sets could no longer be supplied; indeed it was believed that very few members of the Club were possessed of an entire series of its publications.

This proposition proved generally acceptable, and it was resolved that the Executive Committee should consult and report to a future meeting.

The Third Field Meeting was held at

CHEPSTOW,

on Tuesday, 18th July. The Members of the Cotteswold Club, though they in the main confine their rambles and researches within the limits of their own county, do occasionally break bounds, and seek "fresh fields and pastures new" beyond their own confines; and thus it seemed good to them on the day in question to make an incursion into Monmouthshire, with a view more especially to visit Mathern and its neighbour Moins Court, which were new to them, with Caldicot Castle and Caerwent, both of which localities had been included in their programme on a previous occasion. The Club, on the present occasion, had the good fortune to be accompanied throughout the day by Dr Yeats, L.L.D., a gentleman resident in Chepstow, and one well acquainted with all particulars relative to those points of special interest which formed the staple of the day's proceedings.

A well-appointed break was in waiting at the Chepstow Station, on the arrival of the train due at 10.19 a.m., when the party proceeded at once to Mathern a village about three miles distant, where is a singularly interesting and picturesque residence of the former Bishops of Llandaff, and a Church which owes its foundation to Meurig or Maurice, the son of

St. Tewdric or Theodoric, in the sixth century. The British were at that time Christians, and being invaded by the Pagans, they were led to battle by Tewdric, King of Gwent, who, a great warrior in his time, had retired into religious seclusion in a cell near Tintern. From this seclusion he was called to the defence of his people, and in a great battle the invaders were completely defeated; but Tewdric received a mortal wound, of which within three days he died, and was buried on the spot where the Church now stands, and the place received the name of Mathern, or "the place of the Martyr." A mural tablet against the north wall of the Church records this history. The visitors found the Church unroofed, and undergoing the process of restoration, which promised to be so chiselled over and renovated as to lose all appearance of antiquity. This is much to be deprecated. The piers in the nave are Early English; but there is one square column of extremely rude workmanship, which may well be a survivor of an earlier Church. Close by is the former palace of the Bishops of Llandaff, now a farm house, and showing signs of neglect and decay, which, without substantial repairs, will, at no distant day, cause it to fall into ruin. It is a noble and most interesting pile of building, dating apparently from about the year 1500.

At a short distance, across a couple of fields, is Moins or Monk's Court, which is chiefly remarkable for an entrance flanked by lofty square towers. For what purpose so large a structure was erected it is difficult to guess, as the house is small and of no importance. Over the porch are the arms of a Bishop, with the date 1609. At the rear of the house is a rectangular space enclosed by a ditch and mound, the latter being on the outside of the ditch; it bears the name of the "moat-field." Can it be that this was an ancient place of assembly? the term "mote" appears to point to it; and the mounds on the further side of the foss may have been banks whereon the assembled tribesmen sat.

From Mathern and Moins Court the party proceeded to Caldicot Castle; a delightful drive, by "hedge-row elms on hillocks green," with lovely prospects over the Severn to

Kingsroad and the hills beyond. Caldicot Castle is always worthy a visit—it stands so nobly—but, like most of these ancient strongholds, which are planted so thickly along the Welsh frontier, it has no tale to tell. In those early days when the Norman settlers held sway, there was many a scene of border foray and fight around these stone structures; but after the first EDWARD had annexed the Principality these fortresses lost much of their *raison d'être*, and they gradually fell into decay. At Caldicot the original Norman "Castellum," or fortified mound, now called "the keep," is still in excellent preservation, and, from the perfection of its masonry, bids fair to last to the "crack of doom."

Caerwent has been so often and so well described that it needs no further illustration. The party here were greatly indebted to Mr YEATS, who brought with him an excellent map, with the spots marked whereat remarkable discoveries had been made. The only novelty was a portion of a tessellated pavement laid bare in a cottage garden, in which, with the usual guilloche ornament, there were fish (? salmons) in the angles. This probably formed part of a bath establishment, of which a portion of the heating apparatus was found in the adjoining field. Some of the party here adjourned to the residence of a neighbouring farmer, to examine a collection of coins—which the spade turns up in abundance—while others made the circuit of the walls of the old Roman fortress, still happily preserved.

On their way back to Chepstow, the party were induced by Dr YEATS to visit an ancient manor-house, now a farm, called Crick, which is of interest in connection with the fortunes of CHARLES I. When the King was in this neighbourhood, in 1645, he had his head quarters at Raglan, and kept up communication with RUPERT at Bristol. RUPERT occasionally crossed the Severn to meet the King; and this house of Crick, then in possession of a gentleman of the name of MOORE, a staunch Royalist, was used as a place of meeting. Hither on the 22nd July, 1645, came CHARLES, attended by the Earls of RICHMOND and LINDSEY, the Lord ASTLEY, and others, and held

council in the hall of this old manor-house, now in a state of crumbling ruin.

After dinner, which was served at the Beaufort Arms, Chepstow, the President read a communication from the Rev. Mr Reader, of the Dominican Priory at Woodchester, announcing the discovery of a club-moss new to Britain, the *Lycopodium complanatum* of Linnæus. Some three years ago Mr Reader, who is an accomplished and persevering Botanist, discovered near Woodchester a *Lycopodium*, which at first he took to be *L. alpinum;* its character however did not altogether agree with that species, though nearer to that than any other British species. He decided to send the specimen to Kew, where it was unhesitatingly pronounced to be the *L. complanatum* of Linnæus, and as such new to the British flora. Mr Reader states that *L. complanatum*, first described as a species by Linnæus, differs from *alpinum* "in its more flattened (complanate) branches, more robust habit, yellower tint, and especially in the fruiting spikelets, which are often in pairs, with large brown ovate toothed scales, and are altogether much more conspicuous than in the allied species. In some foreign examples the spikes are truly pedunculate, but in our plant they are more properly called sessile, though the remarkably attenuated ends of the branches give them somewhat the look of being stalked. The Gloucestershire specimens proved to be identical in appearance with South American ones preserved in the Kew herbarium." Mr Reader adds that he "found the plant on sandy ground (not on the oolite) amid *L. clavatum* and a flora which recalls that of the Forest of Dean, and has little or nothing in common with that of the Cotteswold hills. At present it forms, with *Cephalanthera rubra* and *Allium sphærocephalum*, one of a trio of Gloucestershire plants which are not known in any other British county.

The Fourth Field Meeting took place at

ANDOVERSFORD,

on Tuesday, 22nd August.

Some time in the preceding month of February some workmen in the employ of Mr Dent, of Sudeley Castle, came upon the foundations of buildings in a wood known as Spoonley Wood. Some tesseræ with Roman tiles being turned up, aroused the interest of Mrs Dent,—a party of excavators was set to work, lines of wall were found and carefully followed, and gradually the remains of a Roman villa were exposed to the light of day, after an entombment of many centuries. It was with especial reference to this interesting discovery that the Cotteswold Club assembled on the day in question.

The morning was fine, and a good many members assembled at the Andoversford Station, where carriages were in waiting. According to their published programme their first visit should have been paid to Sevenhampton, but on the suggestion of one of the party that at Whittington was a Church and manor-house worth seeing, a short deflection from the direct line of route was made for the purpose of visiting them. In the Church there is some Norman work at the west end, but the principal objects of interest within its walls are three monumental effigies and a "brass." The effigies are those of two Knights and a lady of the 14th century. The former are habited so exactly alike that there can be little doubt of their being the work of the same hand. They are armed from head to foot in what appears to be "cuir bouilli"—not plate. The head-pieces are round, with a gorget, which takes the form of the "camail;" they both wear over their armour a long robe or surcote, and bear on their shields five lozenges, three, two, and one, with a label of three points. These are said to belong to the family of De La Croupe, who were seized of the manor in the reign of Edward III. The "brass" is to the memory of one Richard Cotton (or Coton, as it is there spelt,) who built the manor-house, in the reign of Philip and Mary, and being (as it is said) killed in a duel, left the building incomplete, as it still remains. The house, now

the residence of the Dobell family, is a beautiful example of the domestic architecture of the period when it was constructed. It is surrounded by a moat, which seems to point to the existence of an earlier building, better constructed for defence than the present edifice.

From Whittington the carriages proceeded to Sevenhampton, where the Church and manor-house were inspected. The former is of Early English date. In a south Chapel is an Early English triplet, with detached shafts, the latter recent and bad. The walls show traces of colour, and of inscriptions, which may still in parts be read. In the manor-house, formerly a country residence of the Abbots of Llanthony, the members of the Club were courteously received by Mrs Lawrence, the relict of the late Walter Lawrence, Esq., who, some years since, in association with Mr Rogers, of Dowdeswell, conducted a series of excavations on the site of a Roman settlement at Wickham Field, near Andoversford Inn, which yielded a large number of objects of iron and bronze, but with little of unusual interest, if we except a bronze statuette of an armed Roman soldier, about four inches in height. It is supposed to have been the figure of a charioteer, as the remains of reins were in one hand, which is raised aloft; but if it were so, no trace of the chariot could be found. Some time was here spent in examining the large collection of objects of antiquarian interest most liberally displayed by the kind hostess, to whom the best thanks of the Society were tendered by their President.

Halting by the way to inspect at Charlton Abbots a fine old manor-house, now a farm, the carriages proceeded, by cross country roads, down precipitous hills—commanding beautiful views over the distant country—to Spoonley Wood. To this the carriages could not approach nearer than about three quarters of a mile, so they had to be left, and a walk over swampy meadows and through quaggy woodland brought the party at length to the Roman villa of which they were in quest. It faces west, and forms three sides of a parallelogram, of which the central portion is about 200 feet in length, and the wings 150. They found the centre and south wing excavated.

They showed many small rooms, among which are three with tessellated pavements, a hypocaust, and a cold bath. A corridor, which has likewise a tessellated floor, runs the whole length of the principal front. One curious feature is the presence of a well, still half full of water, in one of the principal apartments, in which are other peculiarities which have proved a puzzle to antiquaries. The principal entrance opens on to the corridor. At a side entrance are two upright stones, the purpose of which does not appear. A broken quern or millstone was found in this apartment, which it has been conjectured was fixed above the two uprights, and that the meal fell into a receptacle below; but nothing like it has been seen elsewhere. The north wing remained still to be excavated. As far as it was then exposed the largest apartments seemed to be on that side—the bath establishment, too, may be there. But little of importance beyond the walls and floors had then been brought to light, some half dozen illegible coins, and a quantity of broken pottery and bones being all that the excavations had, up to that time, yielded. The villa cannot be ranked among the larger and more important "finds" of the same kind, and may well have been a "*villa rustica*," or larger kind of farm. It lies about two miles from the ancient "Salt-way," and a Roman camp crowns the neighbouring hill.

A drive of about seven miles brought the party to Naunton Inn, where an excellent cold dinner was served. While at dinner rain came on, which gradually increased to a regular down-pour, in which the party left Notgrove Station for their several destinations.

The First Winter Meeting was held in the Lecture Theatre of the

SCIENCE SCHOOL, IN GLOUCESTER,

on Tuesday, 21st November, when Mr Lucy read a Paper on "The Terrace Gravels of Auchnasheen, Ross-shire." Mr Lucy began by describing the position of Auchnasheen, as situated about mid-way between Dingwall and Strome Ferry. The

terraces of gravel to which Mr. Lucy's Paper referred occur near the outlets of Loch Roshk and Loch Ledgowan, which lochs are separated by the high mountain of Leonach. There are three well marked terraces, of which the uppermost is by far the largest. Its height is about sixty feet; the second terrace is twelve feet, and the third six feet; this latter is quite recent. The upper terrace is covered with peat, in some places four feet thick, and in it are large roots of trees. The second terrace is also covered with peat, but of less thickness. In both terraces are large boulders of quartz, granite, gneiss, trap, Laurentian and metamorphosed Silurian rocks, full of mica. There was abundant evidence of ice-action all around. The gathering-ground of the ice which passed into Loch Roshk was Glen Docharty, Ben Fin, and the adjacent mountains; and that which passed into Loch Ledgowan was derived from the mountains parallel to the loch. The ice-borne masses formed moraines, by which the water was dammed back to a point at which it overflowed, and in process of time planed down the *débris* until they formed the present level surface of the upper terrace. In process of time this terrace was cut through to the depth of sixty feet, when another barrier of smaller size was formed by the same agency, and a period of rest ensued. A similar process was again repeated, and the lower terrace was formed, which represents the highest flood level of the present rivers. Mr Lucy, after some remarks on the Geology of the district, which corresponds with that of Sutherland, with the exception of the absence of lias and oolite, called attention to the evidences of ancient forests, as shewn in the huge roots of trees found everywhere under the surface soil, and in the peat deposits, as contrasted with the present remarkable absence of trees. At Ledgowan there are evidences of four successive forest growths, one above the other. Mr Lucy referred the age of the peat-forest to post-glacial times, after the period of the low-level gravels, and quoted a French writer, M. Belgrand, in support of his views.

Mr Lucy's Paper was followed by one by Dr Wright, F.R.S., on "The Discovery of an Ancient Jar filled with

Mercury, in the Island of Fetlar," one of the Shetland Islands. The facts attending the discovery were these. In an exposed bay, wherein the winds have piled up cliffs and dunes of blown sand, the fall of a portion of the cliff exposed to view a hole. A farm lass, noticing the hole, put her hand in, when her finger entering the neck of the bottle, she ran to acquaint the shepherd, who solved the mystery by bringing to light a bottle, the weight of which astonished him, as he could with difficulty raise it. On examination it proved to be filled with quicksilver, and weighed 100 pounds. The bottle, which holds about a gallon, is of earthenware, of the kind known as "Grès de Flandres," or "Greybeards," a ware which was introduced into this country about the end of the 16th century, probably at the time of the wars of Elizabeth in the Low Countries, and was in common use during the following century. No further history attaches to the bottle. It is a very pretty specimen, which Dr Wright has had photographed for the Club "Transactions."

The President next drew attention to two sword-shaped iron implements, which had formed portions of a hoard of 147, found twenty-three years since, within the ancient intrenchment of Salmonsbury, near Bourton-on-the-Water. Similar implements have been found elsewhere, at Montacute, in Somerset, at Hood Hill, at Spettisbury, and at Pimperne, all in the neighbourhood of Blandford, and lastly at Milborne St. Andrew, near Whatcombe, Dorset. They are all of the same type, and present the appearance of sword-blades in an unfinished state. They measure about two feet eight inches in length by two inches in width and one-eighth of an inch in thickness; but they have this peculiarity, that where the tang or tongue for the handle should be, the iron is turned over so as to form a short socket, which is too small to admit the little finger. They have been a great puzzle to commentators; but the weight of evidence—which is of a negative character—seems to point to their being of the Celtic period. One of those found at Bourton was tested by heat in the forge, and beaten out, when it proved to be good hard steel. The President

announced his intention to deposit the two Bourton blades in the Gloucester Museum.

The President next brought under the notice of the Club the interesting fact of the occurrence of the Long-tailed Duck *(Harelda glacialis. L.)* at Elmore, where an immature specimen had lately been shot on the inundated meadows. This is a rarity on our coasts, especially so far south, and its presence so far from salt water is very remarkable.

The Second Winter Meeting of the Club was held in the Theatre of the

SCIENCE SCHOOL AT GLOUCESTER,

on Tuesday, 12th December, to hear a Paper which had been prepared by Professor Harker, of the Royal Agricultural College, Cirencester, on "The Green Colouring Matter of Animals, with recent researches on Symbiosis."

The Lecturer began by making reference to *Englena viridis* and its allies, of which some effective representations upon a largely magnified scale were suspended on the walls. This microscopically minute organism belongs to the family of *flagellate Infusoria*, which form a greenish slime on stagnant waters. It has a mouth and stomach, and is furnished with a long "*flagellum*" or whip-like process, by the rapid vibration of which it progresses through the water. Within the body are certain amylaceous or starchy bodies, and it is coloured green by chlorophyll. It has long been known that the green colouring matter of plants (chlorophyll) is not confined to the vegetable kingdom, but occurs in various animals. So long ago as the end of the last century Priestley obtained oxygen from *Englena viridis*, and this was held to be proof of its vegetal nature. In certain green planarian worms, Schultze, forty years ago, found chlorophyll. In the well-known fresh-water polyp *Hydra viridis*, and the fresh-water sponge *Spongilla fluviatilis*, the green colouring matter was examined spectroscopically by Ray Lankester, and determined as chlorophyll, while Mr Sorby has made an elaborate investigation into the

nature of the chlorophylloid colouring substance of *Spongilla*, in which he has determined its compound characters as agreeing in this respect with the chlorophyll of plants. In a planarian worm common on the sea-shore, GEDDES found that on exposure to light from 45 to 50 per cent. of oxygen was given off. The Lecturer next proceeded to relate certain experiments of his own on the nature of the green colouring matter of *Englena viridis*. At a lecture at Stroud he mentioned his desire to procure pure gatherings of *Englena*. This bore fruit, and Mr HOLLAND sent a gathering which proved to consist entirely of *Englena*. These were treated by Mr HOLLAND as if for the chlorophyll of plants, when it was found that the re-action, both chemical and spectroscopic, were those of chlorophyll. Further, he found that the colouring matter was a compound, as in the *Spongilla* examined by SORBY. These experiments were repeated with the specimens sent, which were further submitted to the action of sunlight, when the giving off of oxygen was detected; but a most careful examination failed to detect the presence of starch. The chlorophyll in *Englena* is diffused throughout the entire animal, and is not in granules, as in *Spongilla* and *Hydra*. The Professor next referred to the "yellow cells" of HUXLEY, in Radiolarians, thought by HAECKEL to be secreting cells, although he found starch in them. In 1871 CIENKOWSKI found that they survived after the death of the animal, and thought them parasitic. In 1881 BRANDT of Berlin regarded them as independent organisms, and gave them the names of *Zoochlorella* and *Zoanthella*, of the nature of *algœ*, and parasitic. Similarly he considered the green cells of *Hydra* and *Spongilla* to be *algœ*. Therefore he concluded that the chlorophyll does not pertain to the animal, but to the parasitic *algœ*. In 1882 GEDDES confirmed BRANDT to a certain extent. He found the walls of the yellow cells in Radiolaria to be *true plant cellulose*, and advocated the theory of mutual interdependence, to which has been applied the term "Symbiosis." In the spring of this year Professor HARKER found in his tank a *Rhabdocœll Planarian*, with green chlorophyll, not resembling any known algal; it lived in distilled

water four weeks. The green colouring matter was in distinct cells, and the presence of starch was very evident on testing. The summary of the new matter in the Paper is as follows:—Detailed examination of the colouring matter of *Englena*, which corresponds with SORBY's examination of *Spongilla*. (2.) The fresh-water *Rhabdocœlla* worm, with the green colouring in special cells which contain starch, and which worm lived in distilled water for four weeks.

A cordial vote of thanks was accorded to the author. Dr WRIGHT, F.R.S., in seconding the vote, expressed his admiration of the clear way in which the Professor had worked out this difficult subject, which, the Doctor observed, was not new to him. He welcomed this Paper as a happy divergence from the dry and dusty roads of Geology into the living lands of nature. But that which the Doctor regarded as most suggestive in the Paper was the discovery of the remarkable facts conveyed in the term "Symbiosis," which seemed to furnish a clue to the very obscure subject of disease-germs, and to the mode by which they may be propagated.

The Third Winter Meeting was held at the

SCIENCE SCHOOL IN GLOUCESTER,

on Tuesday, January 30th, 1883, when Mr G. EMBREY read a Paper on "Variations in Starch Granules."

After reviewing the mode in which plants obtain their food, and making especial reference to the production of starch, attention was directed to the following summary of the general characters by which starch granules may be distinguished from one another, and their source determined.

1st. Those obtained from the roots, rhizomes and stems, are ovate in form, have excentrically arranged rings, the nucleus at one end, polarise powerfully, and have an unsymmetrical cross.

2nd. Those obtained from the seeds of leguminous plants are elliptical in form, rings concentric, an elongated nucleus, polarise moderately, and show a cross by the union of two crescents.

3rd. Those obtained from the seeds of grasses are spherical, nucleus central, rings concentric, polarise feebly, and have a symmetrical cross.

In mounting starch granules it is advisable to prepare two slides for microscopic examination, one in dry cells for the study of rings and nucleus, and a second in a solution of Canada balsam in benzole for polarised light.

The Fourth and last Winter Meeting of the season was held at the

SCIENCE SCHOOL IN GLOUCESTER,

on Tuesday, 27th of February, when a Paper was read by Mr Edward Wethered, F.G.S., entitled "Further Notes on the Geology of Drybrook." The section known as the Drybrook Section is figured in detail in the fourth volume of the "Transactions" of the Club, from the measurements of Mr. Lucy and the late Mr John Jones. These beds, 149 in number, and measuring some 300 feet in thickness, are intermediate between the "Old Red Conglomerate" and the "Carboniferous Limestone Shales," and consist of a series of light sandy beds, and light greenish coloured calcareous Shales, to which Messrs Lucy and Jones gave the name of "Transition" beds. Mr Wethered stated that he had examined these beds in detail, and found the Sandstones to be composed of the constituents of granitic rocks, while he believed that the Limestone in the Shale was indicative of life, which however had been dissolved away beyond recognition by the percolation of water, charged with carbonic and vegetable acids. The Sandstones pass into a succession of Limestones and Shales; the actual junction is, unfortunately, not exposed, but that which is, contains abundant remains of life. Special attention was called to the bed which the author has named the "Polyzoa" bed. This is a cream-coloured impure Limestone, crowded with stems of *Poteriocrinus crassus*, together with a few *Rhynconella pleurodon*, *Rhabdomeson gracile*, *Fenestrella tuberculata*, and *Ceriopora similis*. But the most important find was that of the jaws of

an annelid, the first discovered in the Carboniferous rocks of this country, though Dr HINDE has recorded two from the "Lower Limestone" Shale of Scotland.

After briefly referring to the Mountain Limestone, and to the Shales which mark the close of that formation, the author passed on to consider the "Millstone Grit." At the part where the section was made the dip was at an angle of 45 degrees, and the lower beds appeared to differ very considerably from the upper. The former were more sandy, and there were flagstones, which the author had not observed in the upper beds. The remains of land plants were numerous, and several casts of shells were obtained; but these, as well as the plant remains, were limited to the first 100 feet of these strata. The author next considered the pebble-bed, to which especial reference had been made in his previous Paper on the Morse section. The opinion there expressed was that it did not belong to the "Millstone Grit," an opinion which had since been strengthened by the discovery of similar pebbles at other places, namely, at Plump and at Bailey Hill, where these pebbles cover a considerable area. The author concluded his very interesting and instructive Paper by correlating the beds which constitute the Drybrook section with the Calciferous Sandstones of the Scotch Carboniferous system. These are represented by Sandstones and Shales, which undergo lithological change in the various localities where they occur. Looking at the "Transition" beds of Messrs LUCY and JONES, the author gave it as his opinion that they correspond in time with the Calciferous Sandstones and Shales of Scotland, and considers that they should be grouped with the "Lower Limestone Shales." In further support of this view it was stated that the Polyzoa mentioned as occurring in the lower Limestone Shales at Drybrook, occur also in the Red Limestone of Arran, which the Geological Surveyors place in the "Calciferous" series.

In the discussion which followed, Mr LUCY spoke in confirmation of the views held by Mr WETHERED, Dr WRIGHT read some extracts from MACLAREN'S "Sketch of the Geology

of Fife and the Lothians," published in 1839, in which the beds under discussion are very clearly defined. The Doctor considered that the correlation of the Drybrook beds with those of the Calciferous series in Scotland was a most important discovery, and showed the value of the work to be done by local Geologists. Professor HARKER, adverting to the annelid jaw, considered it to be a most interesting discovery, and that the character of the organism had been correctly determined.

Mr LUCY brought for exhibition a pair of antlers of the stag (*cervus elaphus*,) which had been found in the bed of the Severn, near Awre, at a distance of a mile from the bank. They are in fine preservation, and of extraordinary size, measuring three feet seven inches from base to tip. The width from tip to tip is three feet one inch and a half, with seven spurs on each. The brow antler measured fifteen inches in length; and the beam measured nine inches and three quarters in circumference at the base. In size this far exceeds the horns of any stag at present existing in this country: examples of the same race are occasionally met with in turbaries, and the dark colour of the portion of skull to which the horns in question are attached, gives reason to believe that they may have been derived from some such source.

Mr LUCY also exhibited a carefully measured section of the Hock Crib on the Severn, and promised a future Paper, with a list of fossils from the different beds.

This was the last Meeting of the season, which was fitly brought to a conclusion by Mr WETHERED's very important Paper. It is fit, too, that I should bring to a conclusion this unusually long Address, which owes its length to the large amount of matter accumulated at our different Meetings, all of which testifies in the most satisfactory manner to the energy and vitality of the Cotteswold Club.

On the Occurrence of the Mineral Vivianite in the Cotteswolds, with remarks. By Frederick Smithe, L.L.D., F.G.S.

I. Introduction.—Not one of the least of the functions of a Natural History Society is to make scientific capital from a diligent and business-like observation of nature. One of our Vice-Presidents, with a warm and earnest enthusiasm, has already attempted to give expression to the idea, by commencing to do something for the minerals of our county, by citing and systematically arranging the names, places and geological position of our more common forms, and so to enlist the attention of scientific observers as not only to obtain a trustworthy census of the minerals of Gloucestershire, some of them already well known, but to bring to light and record the rarer and less obvious kinds;—for there is good reason to suppose that many species one could name as almost certain to exist in given localities in the county have yet to be brought to book, and be catalogued. A case in point is that now laid before the members of the Cotteswold Club, as a small instalment towards Mr Lucy's list, in his suggestive article, lately published in the "Proceedings" of the Cotteswold Natural History Field Club, (1881-1882,) page 30, entitled "On the Minerals of Gloucestershire, with part of the adjacent Counties of Somerset and Worcestershire, compiled by Mr W. C. Lucy. Also a list of the Derived Rocks found in the Northern Drift Gravel over the same area. By Mr W. C. Lucy."

The mineral now exhibited, as an addition to the catalogue, is a specimen of Vivianite (Hydrated Phosphate of Iron,) of which a small portion was last year found by a young friend, Mr J. Marsden, at Bowbridge, near Stroud, and was sent to me, with fossils and other natural history specimens, &c., to be named. Amongst these objects was the mineral Vivianite, occurring, in the non-crystallized or earthy state, as a bluish

green incrustation, deposited upon a fragment of the shelly Oolite of the neighbourhood, and it is here recorded with much pleasure as a native product, to be inserted in the list of the mineral species of Gloucestershire.

The species given in the list referred to are, for the most part, of a sober cast, including few if any of the fairer forms of inanimate nature, and certainly "no agate stone, fit for the fore-finger of an alderman." Still, apart from any value in itself, we may fondly hope that the unexpected discovery of Vivianite will quicken the student to gain power of vision and acuteness in detecting similar objects.

A few remarks may be here offered concerning the components of the hydrated phosphate of iron. The sources of the elements of this combination of oxide of iron and phosphoric acid are clearly evident. The phosphoric acid must have been derived from the shelly detritus and the ochraceous matter of the Oolitic rocks; for ochre or limonite is a variety of hydrated oxide of iron, containing from 30 to 60 per cent. of iron oxide, and is apt to be combined with phosphoric acid, supposed to be derived from the decayed vegetation in swamps, acting on the oxidated iron of the adjacent rocks. Umber, said to be found abundantly in the Forest of Dean, is also an earthy variety of it, containing manganese. The union between the phosphoric acid and the iron is effected in nature's laboratory. Phosphoric acid, on account of the number of its modifications and the facility with which it lends itself to form organic compounds in the animal system, has been designated by an eminent chemist the organic acid—a veritable harlequin in disguise. Whilst iron, the other element in Vivianite, has been termed, *par excellence*, the organismal metal, having its special value in the animal economy;—bones, shells, tissues, and even the blood itself, contain ferric oxide. Its presence has not been unnoticed by the poets. Tennyson, in "The Princess," makes the father of his heroine exclaim, when his stately daughter shows no sign of relenting toward the wounded Prince—

> "I've heard that there is iron in the blood;
> And I believe it."

For convenience, and to save the reader the trouble of turning to the pages of a text-book, a short description of Vivianite, otherwise known as Blue Iron Earth, or Native Prussian Blue, may be of service.

II. Description.—Vivianite: ($3\,FeO, PhO^5 + 8\,HO$) formula, (Blue Iron Earth.) When crystallized it belongs to the Monoclinic system, and has a hardness of 1·5 to 2, with a specific gravity of 2·6 to 2·7. In colour it is usually bluish, or bluish green. The crystals are generally green when seen at right angles to the vertical axis, and blue when parallel to it; the streak is bluish, with a lustre pearly to vitreous, transparent to translucent, and opaque on exposure. Besides the crystallized state of modified oblique prisms, which mostly occur in metalliferous veins, it is found in radiated, fibrous, reniform, globular and earthy states (Blue Iron Earth,) and often found coating bodies and as incrustations. This earthy variety is not uncommon in peat mosses, especially where animal substances have decayed; and, according to Prof. A. Geikie, it is sometimes to be observed as a coating on fossil fishes, not unlike the bloom on a plum. The chemical composition of Vivianite is computed as—

Hydrous Phosphate of Iron	
= Protoxide of Iron	42·4
Phosphoric Acid	28·7
Water	28·9
	100

It is found at St. Agnes, in Cornwall, Bodennais, in the veins of gold mines of Vöröspatak, in Transylvania, and in the United States. The fibrous varieties are found in basaltic lava in the Isle of France, near Kertsch, in the Crimea, and Mullica, in New Jersey. In peat swamps in the Shetland Islands. In the Isle of Man occurring with the horns of the elk and deer. It also occurs in clay, mud, and peat; and, as in the present example, upon fossil shells at Bowbridge, near Stroud, Gloucestershire.

III. History.—Not incongruous, or unconnected with this subject, is the history of Vivianite in reference to a particular line of research, that of Experimental Mineralogy. The credit of the distinction which this department has earned is mainly due to the French chemists, and to the subsidies afforded by the Government to the laboratories in Paris. It has for its aim the artificial re-production of rocks and minerals; and the operations involved in the experiments are far too costly to be undertaken by private workers in general; for instance, sometimes it means keeping quantities of refractory material in crucibles up to a constant white heat for weeks together.

A glance at their experience in the way of re-production of Vivianite,—I translate from a recent publication, "Synthése des Mineraux et des Roches, par F. Fouqué et Michel Levy." Paris, 1882, page 257.

Date of the re-production of Vivianite:—

By Becquerel, in 1861. (Ann. de ph. et ch. t. LIV, p. 149;) and by Debray, in 1864. (C. r. t. LIX, 1864, p. 40.)

Accidental re-productions of this mineral have been not unfrequently noticed. Haidinger has described a case that fell under his notice, in which it was found in the bones of a skeleton, dug up under the ruins at Tarnowitz. Nicklès found it in the tibia of a skeleton, obtained from the cemetery of Eumont; it appeared as a blue substance, which, seen under the microscope, was recognised by him as consisting of orthorhombic prisms of Vivianite. Schlossberger submitted to chemical analysis a blue substance which had been developed, in contact with the air, upon some iron nails that were extracted from the stomach of an ostrich, and he determined that this substance possessed the composition of Vivianite.

It appears that the artificial re-production of this mineral is effected whenever plates of iron are plunged into an aqueous solution of phosphate of ammonia; the plate becomes covered with a white crystalline deposit, possessing the composition and physical properties of the natural hydrous phosphate of iron.

M. Daubrée has described its presence, under the form of a blue coating, on the surface of ferruginous objects found in the

hot springs of Bourbonne-les-Bains. Finally, Vivianite has been observed in the products of the coal pits of Commentry, when under combustion, where it appears to be the result of an alteration of *rhabdite* (phosphure de fer météorique.) Vivianite has been obtained by Becquerel by bringing gently into communication two solutions that were suitable, by their mutual re-action, to generate this mineral. The operation was made in a V formed tube, one of whose branches contained a solution of sulphate of copper, accompanied by a plate of copper, to maintain it in a saturated state, and of which the other branch of the tube enclosed a solution of phosphate of soda, with a thin plate of iron immersed. Between these two liquids a layer of clay was interposed, whereupon a phosphate of copper was produced, which the iron decomposed slowly, and in measure of its production, and on the surface of the iron plate a group of crystals was developed, which had the composition of Vivianite, and, like it, assumed a blue colour on contact with the air.

M. Daubrée has also obtained in the laboratory of the College of France, in 1861, some delicate crystals of Vivianite, similar to those of Commentry, by subjecting to feeble variations of temperature the amorphous precipitate which is produced by bringing into contact two solutions, one of sulphate of iron and the other phosphate of soda, the latter salt being in excess.

To Forchhammer is due the artificial re-production of a crystallized phosphate of iron which only differs from Vivianite in being anhydrous. This substance is obtained by melting together a mixture of sulphate of iron, phosphate of soda, and chloride of sodium;—after washing and decanting the residuum which is formed, a crystalline powdered substance is left, whose composition is represented by the formula: $3\ FeO, PhO^5$, and which assumes on exposure to the air the bluish colours of the natural mineral Vivianite.

The application of the foregoing results to Geology is this—Vivianite appears to be re-produced in nature after the manner of secondary minerals, by a double decomposition. This natural

procedure is no other than what has been generally employed by the chemist in artificial re-productions, and it affords especially fine crystals when the materials are subjected in the process to variable but high temperatures.

The Terrace Gravels of Auchnasheen, Ross-shire.

By W. C. Lucy, Esq., F.G.S.

During the last three years I have stayed some time at Auchnasheen, and as the Gravel Terraces there are the most remarkable I have ever seen, and as I am not aware that they have been described, I propose to give a brief account of them, as they contribute much to the history of the Quaternary Deposits in our own district.

The route to Auchnasheen is *via* Inverness and Dingwall, and after leaving the latter Station, on the Firth of Cromarty, the line rises considerably to Strathpeffer Station, after which it runs by the side of several beautiful lochs, and at Achanalt, eight miles from Auchnasheen, it enters a wide valley, with the lofty mountain of Scuir Veuillin, rising 3000 feet above the sea on the one side, and a high range of nearly the same height on the other.

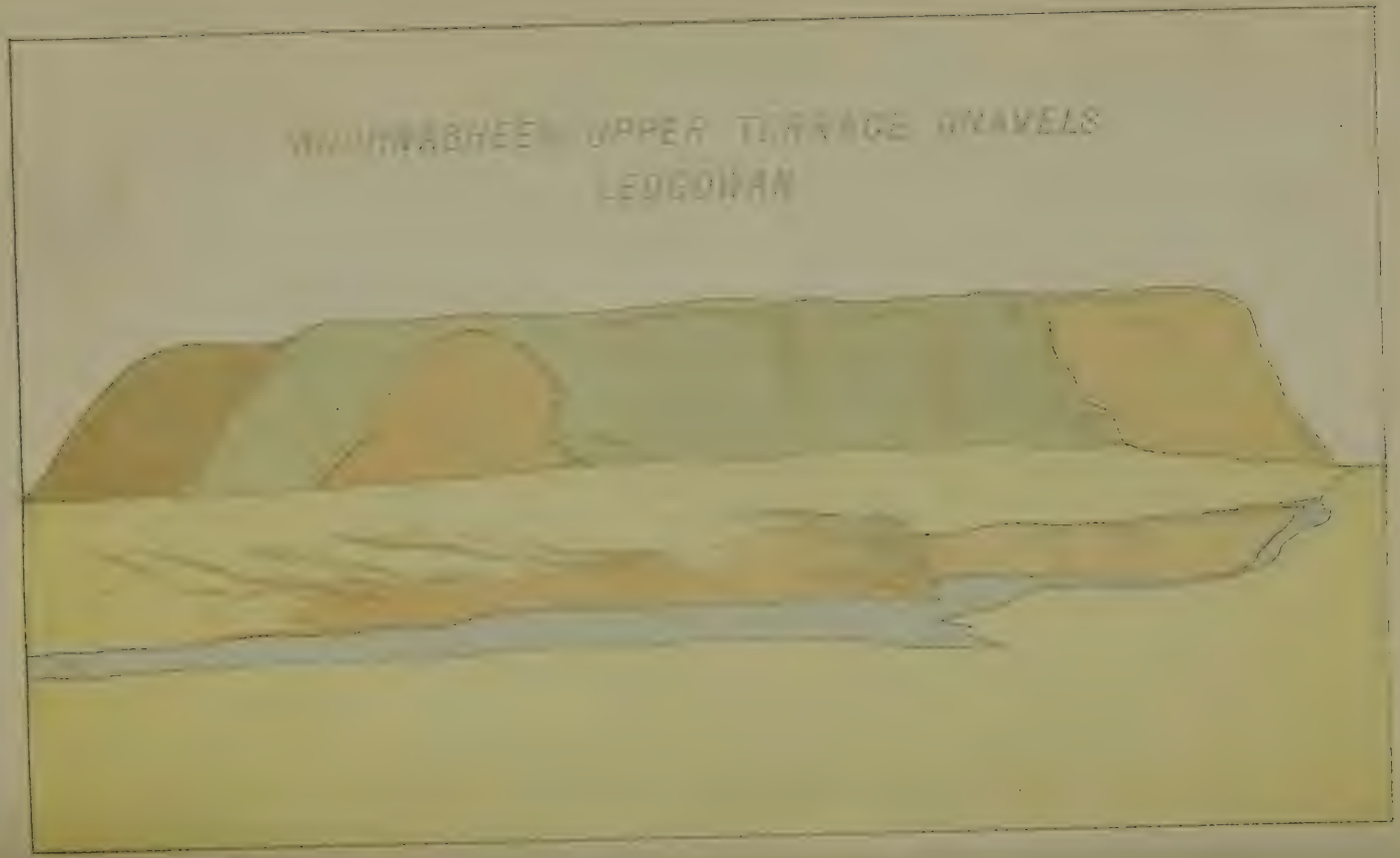
Auchnasheen is about thirty miles from Dingwall, and at the Railway Station is 505 feet above sea level. It is situated where two ways branch off; the one by Railway to Loch Carron and Stromeferry—the place of departure for Skye—and the second by road to Loch Maree and Gairloch.

On the Stromeferry route, within a mile and a half from the Station, is Loch Ledgowan, a mile and a quarter in length; and by the other way is Loch Rosque, a mile from the Station, and four miles long. The two Lochs are separated by the mountain of Leonach, 1521 feet high, and their outflow joins at the Bridge, which is the commencement of the Bran river.

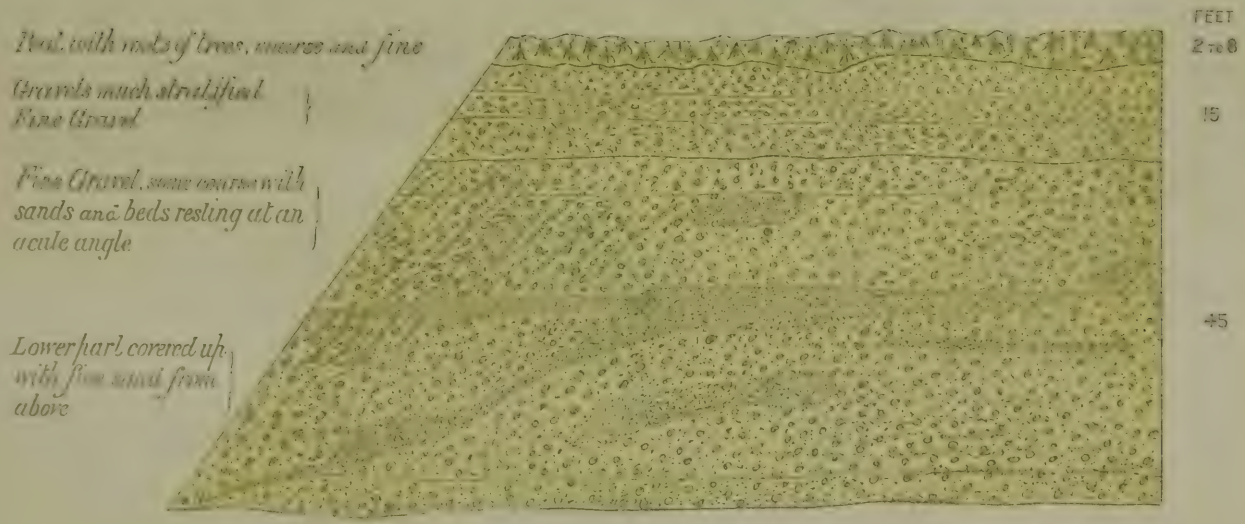
The Terraces begin not far from the junction of the two streams, and reach nearly to both Lochs. There are three well marked divisions, of which by far the largest extends for three quarters of a mile as Ledgowan is approached, and is fully sixty feet high, with sloping sides. The second is twelve feet, and the third about six feet; the latter is recent. *(See Section* 1.*)*


AUCHNASHEEN
LOCH ROSQUE AND LOCH LEDGOWAN

SECTION No. I



LEDGOWAN


Peat, with roots of trees, coarse and fine
Gravels much stratified
Fine Gravel
Fine Gravel, some coarse with sands and beds resting at an acute angle
Lower part covered up with fine sand from above
FEET
2 to 8
15
45


AUCHNASHEEN TERRACE GRAVELS
LOCH ROSQUE

The upper Terrace is covered with peat, varying from two to eight feet in depth, in which are large roots of trees, and the second Terrace is also covered with peat, of about the same thickness.

Section No. 2 shews the first Terrace, at a place where gravel is taken away for the Railway, to which it adjoins. The Terraces contain huge boulders of Quartz, Granite, a good deal of Gneiss, Laurentian Trap, and a large quantity of metamorphosed, supposed to be Silurian rocks, full of Mica, of which the mountains near are mainly composed.

The evidence of ice action is abundant, and some of the large Gneiss rocks weigh fully half a ton, are polished smooth, with not an angle left. The Crystalline Schists are very Micaceous, often small in size, and, when water worn, assume very much the appearance of Celts.

The Section No. 3 shews the Terrace at Loch Rosque, which is much smaller than that of Ledgowan.

On the sides of both Lochs are remains of Terraces varying from 50 to 100 feet, or even more, above the highest Section I have shewn, and at all levels along the mountain sides are enormous boulders and masses of detached rock.

The question naturally arises—How were these Terraces formed, and to what period do they belong?

My impression is that the upper Terrace Gravels date their origin from the time when icebergs were floating about, tearing up, when they grounded, huge masses of rocks, which, on the re-elevation of the land, when snow was able to rest upon the surface of the ground, would become frozen in winter, and form land ice. The summers would be short, but the heat probably great, as is the case at the present day in Norway and Sweden. The ice would slide forward, carrying with it not only the *débris* which the bergs had left, but also tearing up the rocks on its way to the lower levels of Lochs Rosque and Ledgowan, and blocking up their outfall.

The water—and, from the melting of the snow, it would be of far greater volume than at the present time—being dammed up, would naturally rise to a point to admit of its

exit, and in doing so would, in course of time, level the gravels, leaving the Terraces as we now see them. The outlets for the water would gradually widen until the barrier was cut down 60 feet, when a period of rest seems to have occurred.

It would appear the outlet again became obstructed, and another levelling took place, and most likely afterwards there was a period of rest, which came to an end, and the barrier was removed, and the third Terrace represents the present level of the rivers during high floods.

I have mentioned that the Terraces are covered with peat, and in the second, by the side of the stream leading out of Loch Ledgowan, Mr Mackenzie, of Auchnasheen, shewed me four stages of growth where, three years ago, he found, two feet below the surface, a large fir stock, with traces of fire action upon it; and, on its being raised, there was a still larger one under it, not charred; and when it was removed, a third was discovered; and, on that being raised, a fourth was seen. In the peat the hazel, birch, and oak have been found.

To allow of so large an accumulation of peat at different elevations, great time must have elapsed since the Gravel Terraces were formed; and I think with M. Belgrand, in his work on "La Seine," the Quaternary period is coeval with the Glacial period, which was brought suddenly to a close with the low-level gravels.

To this Quaternary period the peat deposits immediately succeed, and owing to the suddenly diminished rain-fall, leaving the rivers clearer, under conditions favourable for the growth of peat, which, he shews, never takes place in river valleys subject to frequent and heavy floods, but always in valleys where springs abound, and floods are few and not turbulent.

There are few things which strike a traveller more than the present treeless aspect of this part of Ross-shire, which was once a vast forest; and I would refer all who take an interest in the subject of the history of the decay of the Scotch Forests to chapter 23rd in Mr James Geikie's valuable work on "The Great Ice Age."

The Great

An Account of an Ancient Jar, filled with Mercury, found in a Cliff near the Sea Shore, at Fetlar, one of the Shetland Islands. By Dr Thomas Wright, F.R.S., L. & E., and G.S., Lond., *one of the Vice-Presidents of the Cotteswold Naturalists' Club.*

The group of Islands comprehended under the general name of Shetland, Zetland, *Hialtlandia*, or the Thule of the Romans, exceeds one hundred in number, but of these only between thirty and forty are inhabited. These Islands are so far separated from the mainland that they have been described as the skeleton of a departed Continent, which once occupied this region of the North Sea. They lie 15 leagues north-west of Orkney, 47 leagues north of Buchanness (Aberdeen,) 44 leagues west of Bergen, in Norway, the nearest point of Continental Europe. Two of the Islands, Fair Island and Foula, are about 20 miles south-south-west, and 117 miles west by south of the most contiguous part of the mainland; all the others form a compact group, and lie 50° 48′ 30″ and 60° 52′ north latitude, and between 52′ and 1° 57′ longitude west from Greenwich. The Islands are chiefly formed of Gneissic rocks, associated with other azoic strata, which were disturbed by eruptive masses of Granite and Syenite. The Gneiss extends from Scalloway Bay through the centre of Mainland and Yell, of which it forms the whole to the north of Unst. This fundamental rock chiefly consists of Quartz, Felspar and Mica. sometimes with Hornblende added, or with Talc in place of Mica. It is laminar, and often distinctly stratified, and at Lambaness is porphyritic. The strike of the beds is west by south.

The Islands which fall more immediately under our consideration are two of the most northerly of the group, Unst and Fetlar. In the latter Island the Jar which forms the subject of our memoir was discovered. Here are zones of rocks

running in a north-west direction. The south-west coast consists of Gneiss, followed by a zone of Serpentine and Diallage rocks, associated with Mica, Talc, Chlorite Schists, from Urie to Tresta Bay. The Serpentine varies in colour from yellowish brown to brownish red, and more rarely to yellowish green. It divides into large irregular blocks of cubical or rhomboidal forms. Dr HIBBERT considers it as unstratified, although it is obscurely so near its regular beds. In the Serpentine Chromate of Iron, a highly prized mineral, from its use in the arts, is very abundantly disseminated in granular particles, like gunpowder; these at other times coalesce into masses of various sizes, some weighing as much as a hundred weight. This valuable mineral was first discovered by Dr HIBBERT, in the hill of Cruciefield, north-west of Balta, scattered in loose fragments over the surface. It is also found in veins, especially near Hagdale and Buness; but detached masses appear the most common.

The Diallage rock consists of this mineral in small grains, disseminated in a basis of whitish Felspar; large crystals also occasionally occur, along with veins of Amianthus, and Dr HIBBERT regards the larger masses as unstratified.

Such is a general review of the Geological structure of Fetlar, which is five to six and a half miles long by five miles broad. In one of the bays along the south-west coast there are low cliffs of loose sandy deposits, which may have been formed by Eolian agency, blowing the fine sand of the sea shore inwards, and in process of time producing low sandy banks along the more sheltered portions of the coast. It was in one of these banks that this Jar was discovered. A part of the low cliff had fallen down and left a gap, into which a little girl passed her hand and detected the neck of the Jar, as related by the shepherd.

THE SHEPHERD'S ANNOUNCEMENT MADE TO LADY NICOLSON.

Something strange—the other day the lass now stopping at Burgh Lodge found a strange shaped Jar in the face of the banks: the Jar would hold about a gallon, and it is full of

quicksilver. The spray of the sea and the weighty rains had brought it in sight. It must have been there for time unknown, and would be about six feet below the surface of solid grass and sand. On the side of the Jar opposite the handle is engraved with droll colours the face, head and shoulders of some great man, as of a King, and the other three sides have medallions ornamented with figures in relief of all colours and shapes.

Hayden Court, 13th Nov., 1882.

Dear Sir,

I do not think I can add much to what I have said about the place where the Jar was found, but I have made an outline in small of the whole Island, and a larger of the particular spot. It is remarkable that the sea boundary of the coast both south and north of this is rock, with exception of the sandy beach in this recess, also the bank, which is its boundary. About six feet above the sea level, even at high water, is also sand, covered with a greensward quite different from the soil of that in its vicinity, or indeed of the Island generally, which is founded on primitive rock-stone, abundant everywhere, with a rather fertile soil. The dotted lines are about the space that is sandy—the spot near where I suppose the Jar to have been found ; the crooked line a brook, that loses itself in the sand ; the outside line the park, of about 100 acres, in which our house stands, with landing at the other recess ; the faint lines high and low water mark. It is just possible that the sea has receded—may have been a deeper bay ; that must be remote indeed. As to the silver ship there is record of probably early in last century ; that was quite on the other side of the Island, almost six miles distant ; I have marked it Hilinabretta. Whether this was carried by hand or sea to the place where found I leave to wiser heads.

And am, dear Sir,
Yours respectfully,
ELIZA NICOLSON.

Dr Wright.

THE JAR.

Common stone ware was first imported into England from Cologne in the 16th century. In one of the Lansdowne MSS. mention is made that in the year 1581 "the potts made at Cullein, called drinking stone potts, were first imported into England by Garret Tynes, of Aken or Acon (Aix-la-Chapelle,) who had previously supplied the Low Countries." As this ware was imported from this region the name "Grès de Flandres"

was applied to it. The stone pots with a bearded mask on the neck, known as greybeards, are mostly of Flemish make. A vessel of this kind was dug up thirty years ago on the site of the old gardens of Westminster Abbey; it was in height 8½ inches and in circumference 16¼ inches. The shape was elegant, but the earthenware coarse, and of a mottled ruddy brown cast, and the design rudely executed; under the neck of the Jar was a grotesque mask, and a medallion enclosing the arms of Amsterdam, the handle was plain and broad. Another Jar was found at Lincoln in the reign of JAMES I., which is also a greybeard. These vessels were called "Bellarmines." The Jar before you is doubtless one of the class of greybeards, and is a very fine specimen of the "Grès Cérame" of BRONGNIART. The earlier specimens of this ware appear to have been introduced into this country from Flanders, about the beginning of the 16th century. The earliest document relating to the importation of such useful and cheap vessels as the Flemish stone does not go back farther than the reign of ELIZABETH, as shewn from MSS. in the British Museum, in a petition from one WILLIAM SIMPSON, addressed to Lord BURGHLEY, to be allowed to import "the drinking potts made at Cullein into this Realm of England, and sell them to any of Her Majesties subjects," for up to this time GARRET TYNES had held the monopoly. The date therefore of the greybeard now before you may be assumed to be about 1600.

Consult JOSEPH MARRYATT, "History of Pottery and Porcelain, Mediæval and Modern," 2nd ed., 1857.

Dimensions.—Height eleven inches and one half, circumference round the belly two feet two inches; it contained the estimated one hundred weight of mercury, of the quality of that in the sample bottle, sent with the Jar for accurate determination, according with my request.

The question of how this Jar of Mercury found its way to Fetlar remains a mystery. There is a story told that a silver ship was wrecked, long ago off, the opposite coast of the Island, but there is nothing authentic on record relating to the event that Lady NICOLSON could discover.

I have given capital photographs of two views of the Jar, now in Hayden Court, which will not only be valuable in our "Transactions," but may lead to more light upon the subject should this Paper fall into inquiring hands; the photographs are permanent, so they will not fade.

On the Green Colouring Matter of Animals, and Recent Researches in Symbiosis. By ALLEN HARKER, F.L.S. *Read 12th December,* 1882.

My object in bringing this very interesting question before the Club is to place on record some few observations, and experiments bearing upon it, which have been made, firstly, by my friend Mr W. H. HOLLAND, partly at my suggestion, and secondly, by myself, in the Biological Laboratory of the Royal Agricultural College.

It has long been known that the bright green colouring matter of plants which, though composed of several distinct colouring matters, is called collectively Chlorophyll, is not confined to the Vegetable Kingdom, but occurs also in certain Animals. PRIESTLEY is said to have obtained oxygen from *Euglena viridis,* whence it was argued that Euglenæ were plants; but the first accurate observations were made by MAX SCHULTZE on a green coloured Rhabdocœle Turbellarian, *Vortex viridis.* I shall refer again presently to this worm in connection with some of my own observations. The list of animals which do contain this colouring matter is gradually being enlarged as our knowledge of the minute forms of life extends. RAY LANKESTER has recently given a list (*Q. J. M. S.*, 1879) of all in which it had been detected up to that date. This list includes an Infusorian, *Stentor Mülleri,* several Radiolaria, Spongilla, Hydra, Anthea, several worms, and a Crustacean.

In some of these the colouring matter is localized in conspicuous granules, in others in much finer granules, while in a third group it is apparently diffused.

To this list it seems not unlikely that many Infusoria will be added when they have been obtained in sufficient numbers to give reliable results. I propose to add *Euglena viridis* to the list, probably several other species, if not all the members of

the genus, and for reasons which it is partly the object of this Paper to give.

Several *Stylonichidæ*, *Phacus*, and *Ophrydium* are invariably coloured green, and probably only await the examination suggested to be likewise added to the list.

Sorby has made a most careful examination of *Spongilla*; he found that the green colouring matter was not a simple one, but could be separated into a blue and a yellow colouring matter, in which he found several other substances, Xanthophyll principally. These were determined by their characteristic bands on spectroscopic examination, their solubility in alcohol ether, and castor oil; and their dichroism.

This is precisely what we know the so-called Chlorophyll of plants to be. What, then, we may ask, is the function of this Chlorophyll, in animals?

In 1878 Geddes, working at Roscoff, found a marine planarian, green in colour, *Convoluta Schultzii*, which, on exposure to direct sunlight, gave off oxygen gas as much as 45 to 55 per cent. The green cells further contained starch in abundance.

With these preliminary facts regarding the question, I now submit a few personal observations.

In a lecture on the *Euglenidae* which I delivered to the Natural History Society at Stroud, some short time ago, the subject of which was the animal nature of those organisms, I suggested, knowing I had several ardent microscopists in my audience, that a search for pure gatherings of *Euglena viridis* should be made. If such could be found I pointed out the interest which would attach to a series of experiments similar to those made by Sorby on *Spongilla*, and that, in addition, the action of sunlight on the animal and the determination of the gas or gases evolved should be carefully noted. This suggestion produced a speedier result than could have been expected. Very shortly after Mr W. H. Holland sent me a sample of a gathering of *Euglena viridis*, exceedingly rich in specimens, and asked me to say whether it was pure enough to satisfy us that any results it might give could fairly be attributed to that organism and none other.

A very searching examination shewed that the sample did not contain *any* other organisms than *Euglenidae*, chiefly *E. viridis*, but with a few of *E. deses* and *Phacus triqueter*. Mr HOLLAND then proceeded to the examination of the bulk of the gathering, which had, I believe, been obtained from an old tub of rain water in the vicinity of Stroud. He extracted the colouring matter with alcohol, ether, and also with castor oil, and obtained by spectroscopic examination the characteristic bands of the green colouring matter of plants. He went a step further than this—he separated out from the alcohol solution the yellow colouring matter Xanthophyll, one of the constituents of the compound colour Chlorophyll. Although I had only a small quantity of the gathering, I proceeded to the examination of the evolved gases under the action of light, and, by an experiment used in the examination of plants, determined the evolution of free oxygen.

I searched diligently for starch, but without success, the so-called amylaceous bodies of SAVILLE KENT giving no starch re-action. We were unable to obtain a further supply of the animal in such a pure state, so our further researches were postponed. We might have proceeded to separate out the varieties of Chlorophyll, but quite enough had been done to prove that the colouring matter which gives the characteristic brilliant green to *Euglena viridis* is identical chemically and spectroscopically with the Chlorophyll of plants.

Some five years ago I noticed that on bringing a basin of tank water into a room, and placing it in a window, the Euglenæ which the water contained collected on the side of the basin on which sunlight was falling, and on arranging the incident beams by means of the window blind, I found that the animals speedily moved into the direct rays, a green tint marking out the particular spot where the animals were congregated from the rest of the surface of the water.

I now refer you to certain views regarding the presence of the green coloured bodies or granules in some of the animals alluded to, as well as to certain yellow bodies which are similarly found within the tissues or structures of other animals.

One of the best known of the marine Radiolaria is *Collozoum*, within the sarcode of which are distributed a number of yellow cells. These have been remarked on by many observers, among others by JOHANNES MÜLLER, HUXLEY, the HERTWIGS and HÄCKEL. The latter, taking them for secreting cells, found starch in them which confirmed his view that they had a nutritive function. CIENKOWSKI first advanced the notion that they were parasitic algae. Dr BRANDT, of Berlin, the most recent investigator, after one or more preliminary papers, published last year, in the proceedings of the Philosophical Society of Berlin, a paper on what he terms the "Zusammenleben" or Symbiosis of Animals and Algae.

He has made experiments on the green bodies in *Hydra viridis*, *Spongilla*, *Stentor*; *i.e.* on some of the animals I have already described as possessing Chlorophyll coloured granules. He has crushed out these green bodies, has found they are not uniformly green, he finds a nucleus in each, and on these grounds he comes to the conclusion that the Chlorophyll coloured bodies are not parts of the tissues of the animals bearing them, but that they are "independent organisms." He further contends that they are capable of carrying on an independent existence, and that it naturally follows that the green colouring belongs not to the *Hydra* or *Spongilla*, but to plants which live within them. He names them *Zoochlorella* and *Zooanthella*.

GEDDES in the meantime, in ignorance of BRANDT's paper, pursuing investigations into the nature of the yellow and green cells, contends too that these are algae, with walls of true plant cellulose, and asserts that the evolution of oxygen from the animals he has studied is due to the plants living with them in this novel association. There is, it is sought to be established, a mutual interdependence between the two organisms; the vegetable cell contributes nutriment to the animal; on the other hand, the waste of the animal's tissue contributes food to the plant; in addition, the evolved oxygen of the plant is beneficial to the animal.

My interest in this question was much increased by finding, in March last, four specimens of a brilliant green *Rhabdocœle*

Planarian in the tanks of my laboratory. I found the contents had been obtained by the gardener from the pond in which the aquatic plants are grown in our botanic garden. I have no doubt it was the *Vortex viridis* of MAX SCHULTZE. I placed two of them in distilled water, and another in pond water carefully filtered. The fourth I kept for microscopic examination. The pair in distilled water lived for 24 days, the one in the filtered water was lost by accident after surviving for more than four weeks. From the remaining one I crushed out the green bodies, and submitted them to the action of re-agents. It is difficult to speak decidedly on one experiment with such minute subjects, but I am persuaded that starch is present in the cells, but further persuaded that they do not resemble any form of algae I have ever seen, either amongst the hundreds of specimens of this or any other pond water examined by me, or in any description of algae seen by others.

I shall look out with great care for other specimens of this Planarian, and submit to you any further observations that may be made by us. It will be manifest that much further observation is needed before we can come to the conclusion that this form of symbiosis is an established fact.

Hock Crib, Fretherne. By W. C. Lucy, F.G.S.
Read Feb. 27th, 1883.

In May, 1853, the Rev P. B. Brodie read a Paper "Remarks on the Lias at Fretherne, near Newnham, and Purton, near Sharpness, with an account of some new *Foraminifera* discovered there; and on certain *Pleistocene* Deposits in the Vale of Gloucester;" and which was printed in Vol. I of our Proceedings.

He did not give a Section, but called attention to having found a *Foraminifera*, which he had submitted to Mr Rupert Jones, who had written to him a note on the subject, and which was added as a postscript to the Paper.

Mr Jones, without giving a very decided opinion, remarked "Provisionally, however, it may be regarded as a *Nummulite*, and, should you see no objection, it may be termed *Nummulites?* liassica."

Mr Brodie also referred to the occurrence there of a new and fine species of the Brachiopod *Orbicula Townshendi:* named after the discoverer.

The present Paper will be confined to a Section of the cliff, with a brief description of some of its organic remains.

The length of the cliff where the Section is taken is 910 yards, and at the S. E. it extends some distance further, forming a low bank, covered with bushes.

It shews evidence of fissures or faults, and foldings; a slight fissure occurs at 523 yards from the S. E., and another 397 yards further on, and a third, of larger size, at 259 yards.

Commencing at the N. W., and where the beds are best shewn, and attain a thickness of 44 feet, and are nearly horizontal,—At this point, when the tides are out, there is a

remarkably fine floor of Lias rock seen, extending into the river fully 50 yards, presenting a clean smooth appearance, much jointed, forming generally long squares, the straight joints running north and south, and dipping under the Severn at an angle of about five degrees. The stone is much denser and harder than the ordinary Lower Lias beds of the district.

This part of the cliff is a good deal exposed to tidal action, and I am informed by Mr Clegram, of Saul Lodge, that within the last half century it has been washed away 50 feet.

The bed of stone No. 5 at the N. W. is not quite continuous, and at the S. E. falls until it forms a shelf or ledge which indicates there about high water mark, and No. 13, following the same course, drops to low water mark.

I am indebted to Dr Wright for naming the following fossils :—

Bed No. 5: *Ammonites Semicostatus*, *Pentacrinites tuberculatus*, *pecten*, probably *textorius*, *Orbicula Townshendi*, *Ostrea*. No. 11 is literally made up of a mass of organic remains, and contains *Limas antiqua* and *Gigantea ; Avicula cygnipes* very abundant ; *Pecten*, full-ribbed, *Rhynchonella variabilis ;* small *Terebratula*, spines of *Cidaris ; Pseudo-diadema* (*Rotatum*) with two plates and many long spines ; *Pentacrinites tuberculatus*, with numerous side arms ; *Ostrea* (small,) *Modiola*, *Cardinia*, *Ammonites Johnstoni* and *Conybeari*, *Gryphæa arcuata*, &c., &c., and some fossil wood.

In No. 13 I found three very large specimens of *Nautilus striatus*, encrusted with oysters.

I submitted several pieces of the beds to my friend Mr Thos. Slatter, of Evesham, who has studied the *Foraminifera* of the Lower Lias, and he failed to find a true *Nummulite*. In No. 5 and 13 he found several *Foraminifera*, *Involutina liassica*.

Pentacrinites occur in No. 17, and are to be found in nearly all the beds.

No. 15 is full of *Gryphæa arcuata*, and they are abundant in No. 5, and indeed are met with throughout the Section.

On reference to the Note-Book in my possession belonging to the late Mr John Jones, I find he has given a general

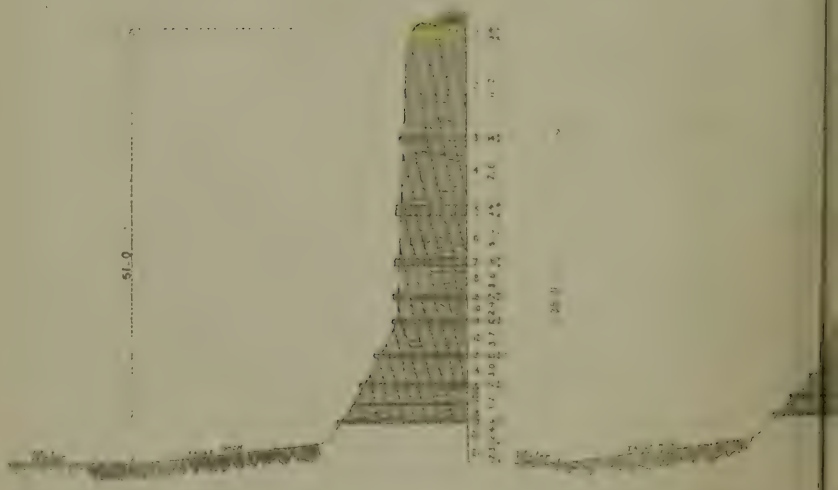
HOC

NORTH WEST

LONGITUDI

Horizontal Sc
Vertical Sca

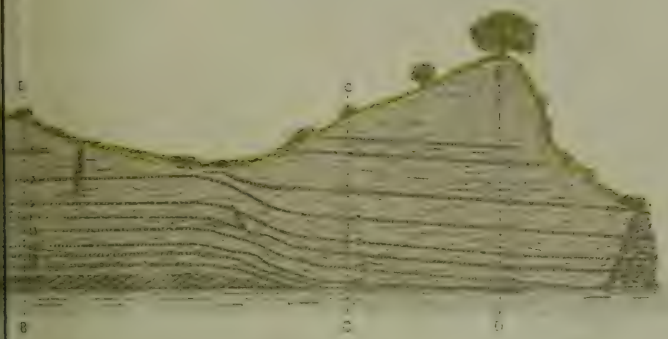
SECTION A.A.



Horizontal S
Vertical Sc

CRIB

SOUTH EAST



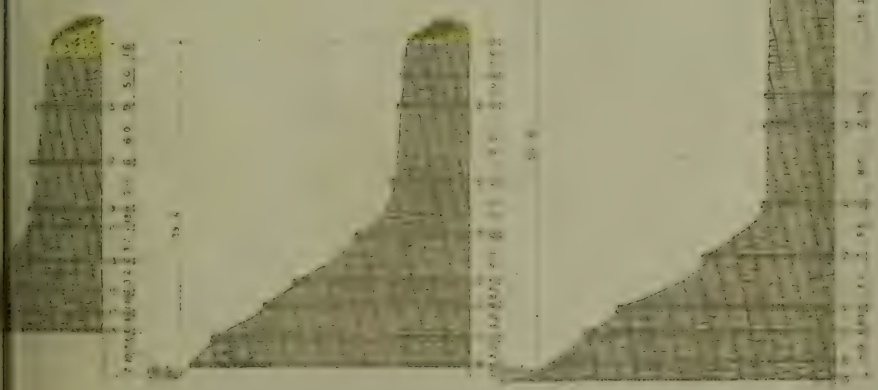
SECTION

400 feet to an inch
0 feet to an inch

SECTION D.D.

SECTION B.B.

SECTION C.C.



120 feet to an inch
0 feet to an inch

Section of Fretherne, made in 1857, and mentions having found *Ammonites angulatus*. In the numerous visits I have made to the cliff during the last two years I have not met with one, but my impression is that *Ammonites* are not so abundant as they were when I first visited the cliff, which would be about that time; and I see in my notes that in November, 1859, I found *angulatus*.

After visiting the splendid Section of Rhætic at Westbury, which is capped with Lower Lias, (the *Ostrea Liassica* bed) Fretherne is very interesting, as it shews beds rather higher in the series, and lower down the Severn at Purton, near to Sharpness, is a low cliff, much worn away the last few years, which comes in due order just above Fretherne.

The Rev P. B. Brodie describes Fretherne as near to Newnham; and so it is, but the latter is on the other side of the river. The best way to go to Fretherne is from Gloucester by steam boat to Saul, from which it is not more than a mile to walk.

Near there is Barrow Hill, from the summit of which is one of the finest views in the district, as it commands the hills on both sides of the Severn.

Annual Address to the Cotteswold Naturalists' Field Club, read on the 23rd April, 1884, by the President, Sir W. V. Guise, Bart., F.L.S., F.G.S.

Gentlemen,—

Another year has fled, and we are again called together to ascertain our position in the past, and to make arrangements for the future.

I have the pleasure to report that the condition of the Club is in all respects satisfactory. Our meetings last season were well attended, and resulted in much interest and instruction, both from our rambles in the field and from the quality of the papers read at our evening meetings.

The Financial Statement by our valuable Treasurer will be received with hearty satisfaction, showing as it does a very large balance—something like £100—to the credit of the Club.

Our numbers are well maintained. We have lost by death during the year Sir Samuel Marling, J. D. T. Niblett, and R. B. Hale; and by resignation, H. Elwes, and L. Winterbotham.

The Annual meeting of the Club was held at the

BELL HOTEL, GLOUCESTER,

on Tuesday, 24th of April, 1883. The chair was taken at 2 p.m., when the President read his Annual Address; after which the usual business, including the election of officers and the fixing of field meetings for the ensuing season, was proceeded with. The President, Vice-President, Secretary, and Treasurer were re-elected. The Treasurer showed that the financial condition of the Club was favourable, but remarked that the list of

arrears was still very heavy. It was resolved that in future no issue of the Society's "Transactions" should be made to Members in arrears with their subscriptions.

At the request of the President, Professor HARKER read a Preliminary Note "on the Development of the Frog," made during the past term in the Biological Laboratory of the Royal Agricultural College at Cirencester. The eggs were taken early in March, at the time when the glutinous coating showed that they were but newly spawned. Experiments were also made with eggs taken from the gravid female, with a view to artificially fertilising them. These had to be further worked out. Specimens of the eggs from the separate lots were taken daily, and hardened for section-cutting. The external appearances each day were noted, and these, on the completion of the paper, would be compared with the internal changes revealed by sections. The points to which special attention had been given were the segmentation of the yolk, the appearance of the *notochord*, and its subsequent development; the growth of the external branchiœ and their subsequent absorption, the opening of the mouth and anus, the appearance of the eyes, the growth of the limbs, and the change in character of the intestines Several interesting experiments were stated to be still in progress on the growth of the Tadpole when supplied with abundant or limited amounts of food, and on the power of sight, and dates of increasing susceptibility to light. A short account of the literature of the subject and a promise of further results were given.

This Paper was followed by one prepared by the Rev Dr SMITHE, of Churchdown; and, in his absence, read by the Rev E. CORNFORD, on the "Occurrence of the Mineral Vivianite in the Cotteswold." Towards the close of the previous year, the mineral in question had been detected by the writers amongst a number of fossils and other natural objects sent for determination by a young friend from the neighbourhood of Stroud. The writer gave a description of the properties and qualities of Vivianite, to which he appended some historical information concerning the mineral and its artificial reproduction in the

Government Laboratories of Paris, taken from a recent work, entitled—"*Synthese des Mineraux et des Roches,*" *par* F. Foque *et* Michel Levy, *&c.* Paris, 1882.

Dr Wright, F.R.S., exhibited for inspection two beautiful specimens of fossil *crustaceans* from the Middle Lias of the Cotteswold.

The First Field Meeting for the season was held at

CIRENCESTER,

on Tuesday, 22nd May, mainly with a view to examine a remarkable section of rock, which had become exposed at South Cerney by a deep cutting on the line of the Swindon and Cheltenham Extension Railway. The party first proceeded to the residence of Mr Bravender, to examine a collection of fossils, which had been recently obtained from the South Cerney Cutting. Dr Wright, after a careful examination of the fossils, remarked that there could be no doubt that they were about to see that day a formation which had hitherto been almost unknown in Gloucestershire, as the fossils proved to be derived from the "Kelloway Rock," so called by William Smith, by whom it had been originally described as occurring at Kelloway Bridge, near Chippenham, in Wiltshire, which he subsequently found in excavations of the Kennet and Avon Canal, near Trowbridge, the Wilts and Berks Canal, near Chippenham, and on the Thames and Severn Canal, near South Cerney; so that the father of English geology had, fifty years ago, detected the presence of the very same formation which had been laid bare in the railway cutting, and which had remained so long unknown to local geologists. The following fossils, characteristic of the Kellovian stage were before them—*Ammonites sublævis Sow., Ammonites Calloviensis Sow., Ammonites Gowerianus Sow., Ammonites Khænighi Sow., Ammonites Herveyi Sow., Pholodomya obsoleta, Phol Terebratula ornithocephala Sow., Rhynchonella inconstans Sow., Gryphæa dilatata Sow., &c.* From hence the party proceeded to visit the church at Siddington, which contains much interesting Norman work.

On leaving the church, Mr Christopher Bowly, of Siddington House, invited the Members to partake of luncheon, which he had prepared for them under the cool shade of some umbrageous foliage, which all enjoyed, as it was both an unexpected and welcome treat. After luncheon the party drove on to South Cerney, to visit the chief object of the day's excursion—the cutting made through beds of Kelloway Rock; and, certainly, the appearance which the beds presented was very remarkable. In the bottom were seen a number of large rounded stony masses, extending in length through two or three hundred yards. The ferruginous sand which had filled the spaces between the stony bosses had been removed, so that the rounded bosses stood out in bold relief in the line of the future railway, from which they had to be removed by blasting with gunpowder—so strange and unusual was the aspect presented by these rocks that the Secretary was instructed to have a photograph taken of the scene for the next volume of "Transactions" of the Club. An attentive examination of these masses showed that they were concretions of a very hard calcareo-siliceous material, which had formed around some organic substances, mostly an *Ammonite* or a cluster of small shells. The rocky bosses had been covered by an oyster bed, which was composed of numbers of *Gryphæa dilatata Sow*, in a state of decomposition; and these fossils were in a stratified layer conformable to the rounded bosses of Kelloway Rock.

A visit was next paid to the church of South Cerney, which contains some good Norman work in excellent preservation. In the churchyard is noticeable a stone altar tomb, with two recumbent female effigies upon it, much weathered and worn; but, from the style of the head-dress, probably as old as the thirteenth century. Some wiseacres, mistaking the veils for wigs, have pronounced them to be judges, and not more than two centuries old!

The next point of interest was the deep cutting at Golden Farm, near Cirencester, in which the clays of the Forest Marble, capped by the Cornbrash, are finely exposed, the Forest Marble clay being almost barren, and the Cornbrash crowded

with fossils; but the rock was so hard and cross-grained that the time at their disposal did not permit of forming a collection.

The Club dined at the Fleece Hotel, Cirencester, after which Professor HARKER gave an account of the chief points of interest that had occurred in the day's ramble, and stated that a series of observations were being made on the beds, which might become subjects for future discussion.

The Second Field Meeting was held at

MITCHELDEAN,

on Tuesday, the 19th of June. The Club assembled at the Micheldean-Road Station, where carriages awaited the arrival of the train from Gloucester at 11.27 a.m. The party at once drove off to inspect the beds known to geologists as the Drybrook Section, on which a paper read by Mr WETHERED had given rise to some controversy. The "Quarterly Journal" of the Geological Society contains a report of this paper, in which some of the leading geologists took exception to the views propounded by Mr WETHERED. It was, therefore, with the object of hearing these explained on the spot that the fixture for the day had been made.

The beds under discussion are a series of arenaceous shales, in variously coloured bands of a grey, green and purple colour, lying between the conglomerate at the top of the "Old Red" series and the Lower Limestone Shales, at the base of the Carboniferous Limestone. Ascending the hill towards Drybrook, these sandy beds occur in that part of the road known as the "Deep Cutting." The first point to be noted was the "Old Red Conglomerate." This is composed of rounded quartz pebbles, known as "veined quartz," which are cemented in a matrix of minute grains of silex and oxide of iron. Special attention was directed to this Conglomerate, because of the occurrence of similar pebbles of veined quartz in the Millstone Grit, which formation occurs some hundreds of feet above. This conglomerate indicates a complete disruption of previously existing conditions, and may fairly be

taken as indicating the termination of the "Old Red" period, a period which is believed to represent mainly a fresh-water, or, in parts, an estuarinæ condition.

Many years ago, Sir Henry de la Beche and, after him, Sir Andrew Ramsay pointed out that the carboniferous rocks in the south-west of England rest on the Old Red Sandstone, which they regarded as constituting the base on which rests the great carboniferous division. But in Scotland the conditions are different—the limestone does not rest immediately on the Old Red series, but upon an intermediate group of deposits, to which the term "Calciferous Sandstones" has been given. "Now," said Mr Wethered, "if we examine the sandy beds before us, we shall find that they are very distinct lithologically from the conglomerate and the sandstones of the "Old Red,' and that they occupy a position intermediate between the latter formation and the limestone shales which follow." These calciferous beds, as they occur in Berwickshire, are thus described in the memoirs of the Geological Survey of Scotland :—"The sandstones at the base of the group pass into a remarkable series of sandy shales in rapidly alternating bands of various shades of green, grey, blue, and a kind of lilac colour; ordinary black argillaceous shale is of rare occurrence." It was pointed out that, both in stratigraphical position and in lithological character, the series of sandy beds in the Drybrook section, correspond closely with the Calciferous series of Berwickshire.

Dr Wright strongly supported Mr Wethered's views, and read a letter from Professor Geikie, written in reply to a request from the Doctor that the Professor would examine the section by Messrs Jones and Lucy in the published "Transactions" of the Club, which elicited from the Professor the reply that he recognised "*the closest resemblance* between the beds below the carboniferous limestone, of Drybrook, and those which we call the Calciferous Sandstones in Scotland."

Passing upwards to Mr Bain's quarry, the party found themselves in the Lower Limestone Shales, in which the beds were crowded with fossils, abounding in Encrinites and

Polyzoa, with *Athyris Roiseyi* and *Rynchonella pleurodon.* Passing over the Mountain Limestone, which is not exposed, they came to a quarry in the "Millstone Grit," a formation which is considered to define the close of that long period which elapsed during the deposition of the Mountain Limestone. Mr Wethered here pointed out that there are in the Forest of Dean a series of beds between the Mountain Limestone and the Millstone Grit, the lowest of which is a coarse crystalline rock, locally known as the "Crease Limestone," which is overlaid by a very characteristic limestone, called the "White Head," or "Lid," so called by the miners because it covers, or overlies, the "Crease" limestone, in which the iron-ore mostly occurs, and is worked at the Edge-Hill mine. To this mine the party drove by a road which, passing by the Wilderness, the residence of Mr Colchester Wemyss, afforded lovely prospects over the Severn Valley, the wide river, and the hills beyond. At the mine, which is worked by the Dowlais Company, the party was most courteously received by the manager. Many of the members availed themselves of the opportunity to descend the shaft—200 yards deep—and proceeded along the underground workings to the distance of nearly a mile. Others resorted to the residence of Mrs Gibbs, the widow of the late collector of fossils for the Geological survey, and made some purchases from her late husband's stock. But all assembled at the appointed hour of five p.m. at the George Hotel, Mitcheldean, where a collation of cold meats awaited their arrival, whence the train at 7.12 conveyed the members of the party to their different destinations.

The Third Field Meeting was held on Tuesday, 17th July. The place of meeting was at

FROCESTER STATION,

where carriages were in waiting. Some years previously the Club had visited Frocester, and a reference to the old Manor-house and the great conventual barn will be found in the

records of the Club at that period; but as many of those present were strangers to the locality, it was deemed well that they should not miss the opportunity of a visit. Mr Leigh, of Woodchester, the present possessor of the estate, conducted the party over the house and grounds. The barn belongs to the period when the Abbots of Gloucester stored therein their tithe corn, and it is all that now remains to tell of those times. The house, which has been largely altered to suit modern habits of life, is not older than the latter half of the 16th century, when the Huntley then in possession entertained Queen Elizabeth, as is recorded in the parish register under date the 10th of August, 1574, when on her way to Berkeley Castle. A room was shewn as that in which her Majesty slept, now completely modernised; but, judging by its size, situation, and approaches, hardly likely at any time to have served as a royal bed-chamber. Be that, however, as it may, the tradition remains, and imparts an historical interest to the old Manor-house.

The carriages now proceeded to climb the steep ascent of Frocester Hill, in the course of which beds are successively passed over, from the Lias in the vale to the lower beds of the Inferior Oolite, at the summit of the hill. These latter beds, which are now much overgrown, have been always regarded as of importance by reason of their presenting an unusually good exposure of the so-called "Cephalopoda bed"—the "Cynocephala stage" of Dr Lycett. The bed is very rich in fossils, of which a list is given by Dr Lycett in his "Cotteswold Hills," presenting, in this respect, at Frocester Hill, a marked contrast to the beds immediately above, which are of a somewhat crystalline character, and besides their "false bedding," here remarkably displayed, are noticeable for the entire absence of fossils.

Leaving Frocester Hill, the carriages conveyed the party to Uley Bury, where at a barn by the roadside they found very comfortable shelter under which to partake of an ample luncheon, which, by the foresight of the Secretary, had been brought in a hamper from Stroud. This over, the party

divided, some going to examine the well-known tumulus, while the rest, under the guidance of Mr Witchell, proceeded to examine a fine quarried section further on. Here they found displayed a fine vertical face of oolitic freestones, from 40 to 50 feet in height, in which Mr Witchell pointed out a narrow band, but a few inches thick, of "Pisolite," which formed a line of demarcation between the upper and lower freestones. Descending a few yards along a wagon-road, in Coaley Wood, they found a man at work with a pick-axe, who had been set on by Mr Witchell to open up a portion of the underlying "Cephalopoda bed," which afforded a rich harvest of *Ammonites* and a large assemblage of *Conchifera*. Amongst the more abundant *Ammonites* were observed—*A. variabilis d'Orb, A. dispansus, Lyc; A. radians, Rein*; and single specimens only of *A. insignis, Schub*; and *A. Discoidea, Ziet;* were found. It had been intended to cross over to Cam Longdown, but rain coming on, this part of the programme was not carried out, and the party proceeded direct to Dursley, where dinner awaited them at the "Old Bell." After dinner Mr Witchell, on the invitation of the President, proceeded to give some account of his work at the tumulus, which he had been engaged in opening in Randwick Wood. The excavations showed an oblong horned barrow, with dry walling outside, and a single wall running down the centre, having two walls radiating therefrom at different angles, and at some distance from each other. The small end of the barrow had at some time been quarried for stone, and the tradition runs that the workmen came upon a human body covered by flat stones, after which they abandoned the work. Outside of the dry walling, the workmen employed by Mr Witchell came upon portions of four or five human bodies, heaped confusedly together, which, from the fact that they were deficient of their due proportion of heads and limbs, were adjudged to have been at some time moved from their original place of deposit and re-buried. Mr Witchell stated that he had already expended about £5 on the work, whereupon the Club agreed that the expenditure of an additional £5 should be sanctioned, and

that Mr G. B. Witts should be associated with Mr Witchell in the further work of excavation.

This brought the proceedings to a close, after which a long and cold drive of nearly ten miles was needed to carry those whose destination lay in that direction, to the Stonehouse station, on the Midland Railway.

The Fourth Field Meeting was held on Tuesday, 14th of August. The appointed place of meeting was the

NOTGROVE STATION,

on the Banbury and Cheltenham line of railway, where the party found carriages in waiting. Attention was directed to the cutting at the station, which shows the Oolite Marl and overlying Ragstones, resting upon Freestones at the base of the section. The carriages thence conveyed the party in the direction of Fox Hill, with a view to examining the "Hawling Lodge Fault," which is described in Hull's memoir of the country round Cheltenham as being "one of the most persistent faults of the district, traversing the country for a distance of at least seven miles from the Lower Lias of the Vale of Winchcomb to within a short distance of Bourton-on-the-Water. The evidence of this fault may be well studied at Fox Hill, where the Freestones of the Inferior Oolite will be found coming against the Fullers' Earth." After a short delay at this point, the carriages moved on. Passing through the village of Naunton, they presently struck the line of the "Buggilde Street," an ancient British trackway, which has been traced in a direct line from the camp at Salmondsbury, near Bourton-on-the-Water, to Alcester. It is accompanied along its course by tumuli on both sides of the way. Halts were made to examine the beds of "Stonefield Slate" at Eyford and at Kyneton Thorns. At Eyford quarries was found a block of stone, on which were, in relief, two curious cellular forms several inches in length, on the nature of which none of those present could throw any light; but opinion was in favour of their being of vegetable origin. I sent the stone for

determination to our colleague, R. E. Etheridge, F.R.S., who stated, in reply, "It is one of the Annelid burrows allied to Scolithus, &c. Some of the so-called plants, *Arthrophycus*, *Buthotrephis*, *Russophycus*, &c., which are Annelid burrows, and casts in the Palæozoic series, are quite the same." At Kyneton Thorns the upper beds have been largely worked for roofing slates by the Romans, of whom traces are found in old workings and all over the adjoining ground—indeed, wherever the ground is moved, pottery, coins, and interments are discovered. The interments are numerous, both by cremation and inhumation, and indicate that there must have been a large settlement on the spot. In an adjoining pasture field, Mr G. B. Witts had caused some excavations to be made on the lines of a building of which the outline of the walls was traceable under the turf of the meadow. It proved to be a building of large size, measuring 280 feet in length by 212 feet in width. In front extended a corridor 17 feet 6 inches wide. It is difficult to determine to what purpose a building of so large dimensions could have been appropriated. Whether Roman or not there was nothing to show; but it was generally assumed to be a Roman work, and in connexion with the adjacent quarries. Leaving this—from which they were driven by a sharp storm of rain—the party proceeded to the village of Condicote, passing on the way Cow Common, with its numerous barrows, described by Professor Rollestone and Canon Greenwell. The church at Condicote proved to be well worth a visit. It has been a very pretty little Norman church, much altered at different times, but still preserving a very ornamental western doorway and chancel arch. Near the village are traces of an early circular entrenchment, the vallum of which is now nearly levelled, and will soon be undistinguishable. How rich is all this district in signs of early occupation! Such is the camp at Eubury, which was next visited. This camp is described and figured in Vol. VI. of the "Transactions" of the Cotteswold Club, by the late G. F. Playne, in his valuable paper on the "Ancient Camps of Gloucestershire." It is strongly fortified, and is remarkable for having an outwork so situated and so

limited in extent as to be at the present time a complete puzzle. The time at the disposal of the Club did not admit of long delay, and the order was given to proceed to Stow, where dinner was awaiting them.

After dinner Mr G. B. Witts read a paper on the exploration of the Randwick tumulous. After describing the structure of the barrow, Mr Witts showed that their search had been rewarded by the discovery of a chamber filled with débris, at the bottom of which was discovered the remains of at least eight individuals; but it was evident that the chamber had been at some time rifled, and its contents scattered—probably in Roman times—for, along with portions of rude hand-made pottery, was found a piece of a vessel which had been turned on a wheel, and part of a Roman horse-shoe. Mr Witts considered this barrow to be of earlier date than that at Uley Bury, but later than that at West Tump.

This terminated the proceedings of the day, and the party returned from the Stow station by the train at 5.34 p.m.

The First Winter Meeting of the season was held in the Lecture Theatre of the

SCIENCE SCHOOL AT GLOUCESTER,

On Wednesday, January 16th, when a paper was read by Mr W. C. Lucy, F.G.S., on "The Birdlip Section, with some observations on the recent boring for water there, by the Gloucester Corporation."

On the table were displayed some grand antlers of the great sub-fossil stag *(cervus elaphus var: strongy loceros of Owen)*; one pair of noble dimensions from the bed of the Severn, near Purton, doubtless derived from the 'Forest' bed; and a single antler, much worn, found during the excavation of the New Docks, at Sharpness.

In illustration of Mr Lucy's paper, were displayed upon the wall some carefully-drawn sections of Birdlip Hill, taken at five different points, which had afterwards been brought into one vertical section of 20 beds. "The sands which form

the base of the section are found at the height of 833 feet, the highest point they are known to reach in the Cotteswold range. These are succeeded by the well-known "*Cephalopoda bed*," and in seven feet the "Pea Grit" occurs, and extends about 30 feet, when the beds become covered up with detritus; the Lower Coral Bed is then met with, containing, on the authority of Mr Tomes, the following corals, *Chorisastræa rugosa*, *Latimœandra Davidsoni*, *Donacosmilia Wrighti*, *Thamnastræa Terquemi*, *T. Defranciana*, *Oroseris concentrica*, *Theocoseris polymorpha*, *&c.* To this bed succeed 70 feet of Freestone, upon which rest the "Oolite Marl," and the "Middle Coral-bed," the latter assuming a dome-like form, which is capped by 20 feet of other beds, the upper of which contains *Clypeus Plotii* and *Terebratula globata*. Mr Lucy compared the section with others in the neighbourhood of Stroud, in which the beds intervening between the "Sands" and the "Pea-grit' are much more developed. He likewise pointed out the absence of the "Gryphite" and "Upper Coral Bed," so well shown at Leckhampton and Stroud.

Mr Lucy's notes on the borings undertaken at the instance of the Corporation of Gloucester, with a view to procuring a supply of water from Birdlip, are of especial interest, and not the less so that the project has for the present been abandoned. There were four bore-holes made, the first of which was sunk at a distance of 1630 feet from the Painswick-road in the upper or "Clypeus" bed of the Inferior Oolite. In this water was tapped at a depth of 195 feet. No. 2 is 1000 feet from No. I., with the surface of the ground 30 feet higher; water was found at 186 feet. No. 3, which is below the escarpment, was an experimental boring undertaken at the suggestion of the Engineer in the belief that a "fault" existed which would give a supply of water at a point much nearer to the present reservoirs at Witcombe; but the operation was abandoned when a depth of 56 feet had been reached, as it became evident that the sinking was not through beds *in situ*, but through a mass of tumbled oolite. No. 4 is at the edge of the escarpment, and is 630 feet from No. 2. The water was tapped at 190 feet, and it rose at once 10 feet, when it attained a permanent level. It

was found in plotting the above sections to scale, that a line drawn through the points in the several bore-holes Nos. 1, 2, and 4, at which the waters assume a permanent level, was a continuous straight line, with a flatter gradient than that of the strata passed through, from which it was assumed that the water had a common source.

Mr Lucy acknowledged how much he had been assisted by Mr Read, the City Surveyor, in the information he had given to the Meeting.

The Second Winter Meeting for the season was held in the Lecture Theatre of the

SCIENCE SCHOOL AT GLOUCESTER,

On Tuesday, 5th of February, when two papers were read,—the first by E. Wethered, F.G.S.; the second by E. Witchell, F.G.S. The subject of Mr Wethered's Paper was "On the occurrence of the Spores of Plants in the Lower Limestone Shales of the Forest of Dean, and in the Black Shales of Ohio, in the United States of America."

Mr Wethered commenced by making reference to a paper which he had brought under the notice of the Club "On the Lower Carboniferous Rocks of the Forest of Dean." In it he had described an argillaceous bed, to which he had given the name of the *Rhychonella pleurodon* bed, because of the abundance of that fossil found in it. At the top of this is a bituminous layer, a few inches thick, in which he detected a number of minute yellow discs. On visiting Drybrook last summer he came across some black shales below the *Rhychonella pleurodon* bed, and in these he detected the same yellow bodies before noticed. A microscopic section of the shale was procured by first hardening the material in Canada balsam, which revealed the fact that the shale was full of vegetable remains.

About this time, Dr Dawson, of Montreal was visiting Cheltenham, and showed to Mr Wethered some spores of plants found in the Black Shales, of Ohio, United States; these Mr Wethered recognised as similar to those found in

the Forest of Dean. The Spores exhibited by Dr Dawson had been discovered by Professor Edward Orton, Columbus, Ohio, and had been referred to in a paper read before the American Association for the Advancement of Science in 1882. The Professor on being written to kindly sent specimens of the shales.

The Ohio Black Shales rest upon the uppermost Devonian Rocks, and represent a thickness of from 250 to 350 feet. The deposit is considered by the American Geological Society as a dividing line between the Devonian and Carboniferous formations, they are of special importance as yielding mineral oils. It is important to note that the horizon of the beds, in Ohio, which yield the Black Shales, are precisely similar to those of the Forest of Dean Shales, which yield the vegetable remains. Identically similar spores have been found by Dr Dawson in the Erian formation of Kettle Point on the Huron, which strata are assigned to the Upper Devonian. The facts are remarkable, inasmuch as they point to a similarity of conditions which ushered in the great carboniferous period, and closed the Devonian over widely separated areas; conditions which allowed of the accumulated growth of vegetation in dense masses, and of close relationship in type. As respects the spores themselves, there is a close resemblance between those from the Forest of Dean and those from America; some are certainly of the same genera if not of the same species. From the Forest two varieties can be made out; those from Ohio are usually of larger size. Some of those from Drybrook show triradiate markings, which is a fact of importance in determining their connection with existing forms of vegetation. In considering this latter point, it would be rash to class them definitely with existing plants, having consideration of our limited knowledge of the vegetation which yielded the spores.

We have then, in the Forest of Dean, the same class of vegetation which by decomposition has yielded the well-known stores of mineral oil in America, and the question naturally arises "Is oil to be got from the Forest of Dean Shales?" The Ohio Shales give from 8 to 22 per cent. of organic matter. A fair example from Drybrook gave 17 per cent., 6 per cent. of

which was volatile. At Drybrook the Shales will not exceed 20 feet thick; the Carboniferous rocks, however, in that district thin out, but there is little doubt that similar Shales of greater thickness will be found in other districts, probably at Clifton and in South Wales.

Professor HARKER said, Mr WETHERED had kindly asked him to examine his slides, and they had together made a study of the remains of plants in the carboniferous beds generally. The minute spore-like body shown with the triradiate markings, was, in his opinion, a microspore of some plant closely allied to *Isoëtes*. An examination of the spore forms of the higher Cryptograms shows that those of *Isoëtes* are the only ones at all resembling Mr WETHERED's specimen. With regard to the larger bodies, with processes and markings indicating a spinous habit, if we asked ourselves what modern plants do they resemble? We were reminded of *Coleochaetœ*, which grow in our aquaria, many of which are spined. Mr HARKER said that Mr WETHERED had been devoting much labour to the study of carboniferous sections, and his researches, especially on the vegetable organisms in certain coal seams, were shortly to be made public, and would further bear out his views as expressed to-day.

Mr WITCHELL then read some remarks on the occurrence in the neighbourhood of Stroud, of the palmate Newt (*Lissotriton palmipes.*) Mr WITCHELL began by referring to a paper by the late JOHN JONES, which will be found in the 3rd Volume of Transactions of the Cotteswold Club, p. 157, in which is given a list of the reptiles of the county, where the Palmate Newt is mentioned as occurring, on the authority of Mr BAKER, in the adjoining county of Somerset, but as totally unknown to the writer. Mr WITCHELL stated that one of his sons found the Palmate Newt in ponds near Stroud, and on looking up its natural history learnt that it was comparatively rare. Further observation, however, has led to the discovery that, so far from its being rare, it is in the Stroud neighbourhood the most common of its genus, in the proportion of 10 to 1. By some naturalists the Palmate Newt is regarded as a variety of the

common Smooth Newt—but the difference was shown to be considerable, both in form and habit. The fact of the comparative abundance of this Newt near Stroud was confirmed by Major FISHER from his own observations.

On the table were placed, in illustration of the two preceding papers, four microscopes, with slides of the sporangia treated of by Mr WETHERED; and two tumblers containing water, in each of which was a living specimen, male and female, of the Palmate Newt.

The Third Winter Meeting of the season was held at the

SCIENCE SCHOOL IN GLOUCESTER

On Tuesday, 11th March in the present year, to hear a paper by Professor ALLEN HARKER, of the Royal Agricultural College, Cirencester, on "A remarkable exposure of the 'Kelloway Rock' in a recent cutting near Cirencester."

In the month of May, in last year, a day was devoted to a visit to the very remarkable beds of which the Professor's paper contained a detailed report. About a mile and a half from Cirencester, near to the village of South Cerney, the new line of rail from Cirencester to Swindon cuts through a hill, which proved to contain within it certain beds of stone of extreme hardness, which have given to the cutting considerable local celebrity, while to geologists it has presented a problem of no ordinary interest. "Taking," says the Professor, "the maximum exposure," the following is a detailed description of the section:—

	ft.	in.
Surface Soil	1	6
Drift Gravel, varying from	2 to 9	
Clay	3	0
Red Sand	1	0
Shelly Band (*Gryphæa dilatata*)	0	6
Ferruginous Sandstone	3	6
Calcareous Sandstone	6	0
Yellow Stratified Sand	8	6
Clay (so far as exposed)	3	6
	30	3

The characteristic fossil of the "red sand" and underlying "shelly band" is *Gryphæa dilatata*. The remains are in poor condition, and crumble on exposure to the atmosphere. The fossils of the "Ferruginous Sandstone" are not much better. It is to the band of "Calcareous Sandstone" that the attention of observers has been specially attracted; indeed, the interest of the cutting may be said to centre in that bed.

An analysis of the rock yielded to the Professor the following results:

	Per cent.
Silica (as insoluble silicates)	60·74
Calcium Carbonate	34·35
Ferric Oxide	1·90
Alumina...	·64

In physical character it is of a slaty blue colour, is intensely hard, and is crowded with remains of animals and plants. These include five species of *Ammonites*, many in splendid preservation. *Lamellibranchs* belonging to the genera *Modiola*, *Pholodomya*, *Myopsis*, *Isocardium*, *&c.*, and two or three species of *Brachiopods*. Perhaps the most remarkable remains are those of plants. Scattered through the rocks are pieces of wood, varying in size from the merest splinters, to pieces, in one case reaching 18 inches in length by 3 inches in other directions. This wood is still in a carbonaceous condition, and crumbles under the knife or even under the pressure of the thumb nail. Sections of this wood were exhibited under the microscope. Another feature of this band of sandstone is its remarkable concretionary character. A section shows a series of concentric coats or shells of regular form round a concentric *nucleus*, which was invariably found to consist of either one or more *Ammonites*, or occasionally of a great number of *Brachiopods* or *Lamellibranchs*, mixed with bits of wood. The presence of so much wood points to the proximity of land, and the condition of the wood supports the theory that the rock was very rapidly consolidated.

Professor Harker next drew attention to the special feature of the cutting which has led to its celebrity. A preliminary boring made by the contractors did not reveal more than a few

inches of the hard calcareous sandstone bed, and it was not until excavations had proceeded some length that its extent and thickness were exposed. It was then found that a deep channel divided this rock into two, exactly on the line chosen for the railway, and that the channel was filled with sand easily excavated, in marked contrast to the sandstone rock, the removal of which proved such an arduous undertaking. As the sand was removed, the deep channel which it filled was exposed to view, and its remarkable features at once became evident. It was shortly after its complete excavation that the Club visited the section, and photographs were then taken. These show the sides of the channel (which varies in width from 6 feet to 15 feet or more) standing in relief; the rock worn into rounded bosses of various sizes, while in some cases huge mushroom-shaped masses stand isolated on the underlying sand. The largest of these is now placed in the garden of the Royal Agricultural College. On the cutting being cleared out, it was apparent that the sand was very regularly stratified. The sand, which was very loosely compacted, contains 1 per cent. of salt. The rock weathers very rapidly. Doubtless some of the sand which fills up the channel was due to the disintegration of the rock itself. The Professor inclined to the belief that we have here an old shore line of the Mid-Oolitic Sea, then slowly sinking, and silting up with its many-coloured sands.

Drawings of the cutting, a detailed section, microscopic and other specimens, illustrative of the paper were exhibited.

The Fourth and last Winter Meeting of the season was held at the

SCIENCE SCHOOL AT GLOUCESTER,

On Tuesday, the First day of April in the present year. Mr Lucy occupied the chair, in the absence, through illness, of the President.

Francis Day, Esq., F.L.S., read a paper on "The Breeding of Fish." After referring to the difficulties of the subject, and

the effect of legislation in promoting the increase of fish in our rivers and inland waters, Mr Day proceeded to describe the migrations of fish, the mode in which the ova are deposited, and the care with which they are watched over by the male fish. He gave an account of some experiments made in the artificial breeding of fish, which showed that different species of the *Salmonidæ* may be successfully crossed, but that experience has yet to ascertain whether the progeny will be sterile or fertile, stationary or migratory in their habits. Experiments, he stated, are being assiduously carried out in Scotland by a single public spirited individual, at his own cost. The United States Fishery Commissioners have demonstrated how sea fish can be artificially hatched as readily as those from fresh waters: while the Fishery Department of the United Kingdom give no assistance and contribute in no degree to investigate the subject of fish culture.

Mr Lucy exhibited a large piece of pumice, which fell, red-hot, on the deck of the Italian barque "Padre Francesco" during the eruption of the volcano Krakatoa, in the Straits of Sunda, in the month of August last. The vessel was distant about three miles from the volcano at the time. This "drop of the crater" has been presented to the Gloucester Museum by Mr E. V. Ellis, the Italian Consular Agent.

Mr Lucy then read a Paper on the sinking of a well at Messrs Robertson's brewery, which was illustrated by a carefully prepared Section. The well was sunk in the expectation that at the depth of 200 feet the Rhætic beds would be reached, but the test of boring, which was made to the depth of 350 feet, showed that at least 80 feet more would have to be passed through before the Rhætics were pierced. Mr Lucy had been consulted prior to the sinking of the well, and, in referring to the error he had made in his calculations, gave his reasons for believing that the Rhætic beds were nearer to the surface than they had proved to be. These reasons were founded upon a knowledge of the surrounding Geological conditions with reference to the Rhætic beds as established at Highnam, Wainlode, Elmore, and other points in the neighbourhood.

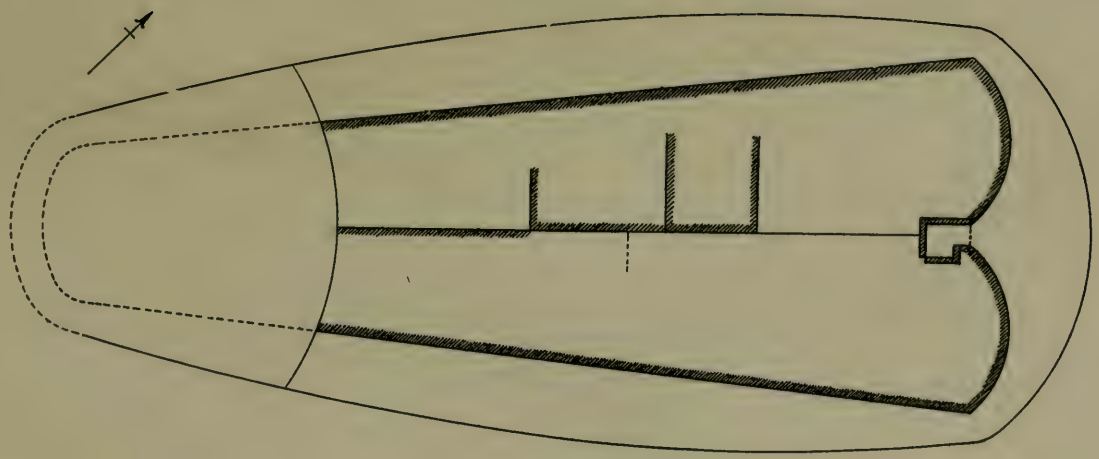
The result of the boring, although very unsatisfactory to Messrs Robertson, is extremely interesting and instructive Geologically. It clearly shows, from the depth of 350 feet having been reached, that the Lower Lias is probably at this point 400 feet thick. Mr Hull in his memoir, at sheet 44, states that under Cheltenham the Lower Lias is supposed to be 600 feet thick, but does not show how that thickness is arrived at, and states that southward, towards Bristol, the thickness is only 300 or 400 feet. The boring has given us more definite information of the Lower Lias in this neighbourhood, and has added to our knowledge much that will be of advantage to future enquirers.

This was the last Meeting of the season, and worthily brings to a conclusion these records of a season's work of the Cotteswold Field Club.

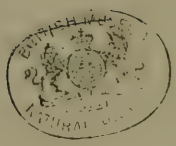
Randwick Long Barrow. By G. B. Witts, C.E.

This Barrow is situated on the top of Randwick Hill, within the entrenchments of an ancient camp. The direction of the mound is E.N.E. and W.S.W., the highest portion being towards the E.N.E. The west end has been destroyed by quarrying operations, leaving the present mound only 113 feet in length: the original Barrow (comparing it with others in the neighbourhood) was probably 185 in length. The two external walls were exposed to view in the quarry at the west end. In July 1883 Mr Witchell and myself directed the labourers to excavate along the outside of the southern wall, commencing at the exposed point in the quarry. After driving a trench about eight feet, we came upon several skeletons laid close to the external wall: these skeletons, though in rather a composed mass, had evidently been buried in the usual sitting posture—this was proved by the skulls and knee-pans (*patellas*) being found together, and the heel bones and heads of the femurs. An examination of the bones found at this point showed that there were nine femurs, and only portions of four skulls, while a medical gentleman declared there were eleven arms—rather a curious combination! With the human bones were a few of the lower creatures, including a peculiar jaw, supposed to be that of the missing link! The southern wall proved to be very much perished, and it was only occasionally that its line could be traced. The northern wall was traced for some distance from the western quarry, and, as far as the examination continued, the wall was intact. On a future day Mr Witchell exposed to view the central line of the Barrow; this consisted of a roughly built wall, in some places 10 to 12 feet in height. For the first 30 feet from the west end this wall faced towards the north; it then came to a transverse wall; for the next 40

RANDWICK LONG BARROW



SCALE 30 FEET TO AN INCH



feet it faced the south; there were also four transverse walls, two of which seemed to form an enormous buttress about 15 feet wide. I quite agree with the late Professor Rolleston, who, in describing similar walls in one of the Swell Barrows, attributes them solely to the neolithic labourer who constructed the Barrow, built up for his own convenience, and that they are very misleading to modern Archæologists, having no connection whatever with the chambers. But from the excellent manner in which the walls at Randwick have been exposed, they prove very valuable in showing the interior construction of a Long Barrow, and I feel sure there is no other example in the county so well calculated to throw light on this point. On August 9th we directed the men to excavate at the south-east end, to try and find the external wall at that point; but it may surprise those who have not personally conducted the exploration of a Long Barrow to hear that we excavated a trench three feet wide right through the wall without seeing it! I have seen this done so often, though under the keen eye of Professor Rolleston, that it was no surprise to me. After vainly endeavouring to find this wall for several hours, in a regular downpour of rain, we attacked the central portion of the E.N.E. end, and were soon rewarded. After excavating to a depth of three feet we noticed the top of a large stone; coming to the conclusion that this was the main entrance, we continued at this spot in August 10. Following the line of the large stone (placed on end) discovered the previous night, we soon found that we were excavating in the interior of the principal chamber, placed exactly in the centre of the east end of the Barrow (E.N.E.,) that, in fact, we were inside the boundary wall, which we had hitherto failed to discover at this point. The chamber consisted of five upright stones (as the plan will show)—

	ft.	in.		ft.	in.			in.	
No. 1 being	5	6	long	3	8	high	and	9	thick
" 2 "	5	0	"	2	0	"	"	10	"
" 3 "	4	0	"	3	6	"	"	9	"
" 4 "	2	9	"	4	0	"	"	10	"
" 5 "	2	3	"	2	9	"	"	4	"

The first thing of interest we found in this chamber, about one foot from the surface, was a piece of Roman pottery, with the mark of the potter's wheel, and a well-formed rim. Shortly afterwards we found a second piece of Roman pottery. Continuing our excavation in the chamber, which was completely filled with Oolitic rubble, we found, two feet from the surface, half of a Roman horse-shoe, and shortly afterwards we came upon a few scattered human bones. On nearing the bottom of the chamber, we found several pieces of very old British pottery, without the mark of the potter's wheel, three flint flakes, and an extraordinary confused mass of human bones, broken up into very small pieces, and utterly defying the greatest expert in giving any opinion as to the direction in which the skeletons were originally laid. Possibly the most remarkable incident connected with this find was that there were no femurs at all, and only a very few small portions of skull. With the human bones were a few of the lower creatures, including birds. The contents of the chamber were minutely examined, in the hope of finding the usual flint arrow-head, or heads, but without success.

Now how are we to explain the presence of metal (a horse-shoe) and Roman pottery in what undoubtedly was the principal chamber of this Long Barrow? Is their presence to upset the theory that no metal, or pottery with the mark of the potter's wheel, has ever been found, or ever will be found, in connection with the primary interment of a Long Barrow? Certainly not; and I venture to put forward the following suggestion as the true explanation. As stated at the beginning of these notes, the Barrow lies within the entrenchment of an ancient camp, and this camp was without doubt occupied by the Romans during their occupation of the country. Finding in the middle of their camp a huge mound, and very probably the large stones of the chamber exposed to view, what would be more natural to the Roman Archæologist than to employ some of his spare time in examining the mound, as we do in the present day? That the Romans excavated in this chamber I have no doubt whatever; and we have probably to thank some far-seeing

Roman officer for the fact that they left their cards! in the shape of a horse-shoe and some pottery, to inform future Archæologists that they had already explored this portion of the Barrow. I further maintain that these Roman Archæologists were guilty of removing the skulls and femurs. And what would be more natural? They found that the skulls were of a remarkable type—clearly defined dolicho-cephalic—and they no doubt presented them as great curiosities (just as we do now) to the museums of Glevum and Corinium! The Romans, however, were kind enough to leave the knee-pans (*patellas.*) and these numbering 14, show that there must, at any rate, have been originally seven skeletons in the chamber.

Having completed our examination of the chamber, and being of course convinced that we were inside the surrounding walls, we next commenced a vigorous attack to bring them to light, nor were we unsuccessful. At a point 20 feet south of the main chamber we found the wall very irregular and difficult to recognise, so much so that one of the party suggested getting a dictionary, and turning to the word *wall*, read its proper definition; but, tracing out the line of our supposed wall on its proper curve to the main chamber, we were at once rewarded by finding it intact, leading in a gentle curve right up to the entrance stones. Alas! we had already passed through this wall in two places without seeing it, but moving a few stones in the exact line which our friend, 20 feet south, pointed to us, revealed the wall in good preservation.

Reverting to the skeletons found near the exterior wall at the S.W. corner, some have supposed that they were subsequent interments of a much later date, but, looking to the decided dolicho-cephalic character of the skulls, and the sitting posture in which the skeletons were placed, I am inclined to agree with Professor Rolleston and Canon Greenwell, that it was the custom to bury slaves and retainers as near as possible to those of their chiefs, and if they were unable to get leave to place them in the Barrow, they placed them as near as possible to the external wall, just as we found them. No less than twelve skeletons were found by me in this position at the West Tump

Barrow (Cranham.) Five flint flakes (rather large ones,) with several pieces of old British pottery, were found in the centre line of the Barrow, about 12 feet from the western quarry, on the original surface of the ground, and with them many burnt stones. I should mention that many of the bones in the chamber were much burnt, some of them being quite black, and many stones showed signs of fire, though many were unburnt. No signs of the stain of manganese were found.

Taking everything into consideration, I should say that the interesting Long Barrow at Randwick is of earlier date than those at Uley, Nympsfield and Notgrove, and later in date than the ones at West Tump, Lower Swell and Eyford.

By direction of the owner, Mrs Barrow (an odd coincidence,) the walls and chambers have been covered up to protect them from damage.

SECTION OF BIRDLIP.

Some Remarks on a Boring for Water near Birdlip, for the City of Gloucester. By W. C. Lucy, F.G.S. *Read Jan. 16th,* 1884.

About two years since I had occasion to refer to our Proceedings, fully expecting to find a complete Section of Birdlip, as I was anxious to compare it with some other Sections of the Inferior Oolite of the Cotteswolds.

Although there were several references made to the various visits of the Club, with general remarks on the beds, yet no details were given, and I therefore resolved to make a Section, in which I have been much aided by two of our members, Messrs Helps and Foster, who fortunately reside at Birdlip, who have accompanied me many times, and who have, at their leisure, kindly checked and confirmed my observations.

After two unsuccessful attempts to give a horizontal Section, I determined to adopt five vertical Sections, made at places easily accessible, and afterwards to shew them in one.

Taking the contour of the hill the distance from

No. 1 to No. 2 is	... ...	120 yards
„ 2 „ „ 3 „	... ...	75 „
„ 3 „ „ 4 „	... ...	115 „
„ 4 „ „ 5 „	... ...	155 „
„ 5 to the top of the hill, near the Inn		275 „

Making a total length of 740 yards, and shewing a dip to the south-east of 27 yards.

Section No. 1

Is made at the north-west promontory, which juts out into the valley, round which is the combe, looking towards Crickley, and it attains an elevation of 897 feet.

Commencing with the top of the Liassic sands, which are here 833 feet above sea level—the highest point they are met with in the Cotteswold range, and which in a subsequent paper I shall have occasion to notice,—the Cephalopoda bed is well shewn, resting upon the sands, full of broken *Belemnites*, and forms a very hard compact stone, from its being cemented together by iron, in addition to lime, and contains *Myacites*, *Ceromya* and *Pholadomya*, *Gresslya*, *Belemnites*, &c.; and the next bed, No. 2, bears a general resemblance to it, but has a more sandy or arenaceous appearance, while No. 3 is more of a limestone, still hard, and at its base shows, in the parting, Pea Grit. 4, 5, 6 are hard bands of stone, with Pea Grit gradually increasing, until, at the top of No. 6, it is abundant; in 7 and 8 it becomes large and well cemented together; and 9 and 10 are shelly limestones, much broken up, and 11 is a rubbly bed, capped with soil.

Section 2

Is taken at Messrs Helps and Foster's quarry, and is 130 feet in a direct line from No. 1, and shews a dip in that distance of 7·65 degrees. The beds all contain Pea Grit largely disseminated, and I consider them the equivalents of 3 to 8 inclusive.

The difference in thickness of the two Sections is two feet, No. 1 Section being 29 feet, and this 31 feet. The lower bed contains numerous large *Oysters*, *Limas*, *Pentacrinites*, *Hinnites*, &c.; and in the bed above *Bryozoa* and *Serpulæ* are abundant, and *Terebratula simplex* and *Pygaster semisulcatus* occur.

Section 3.

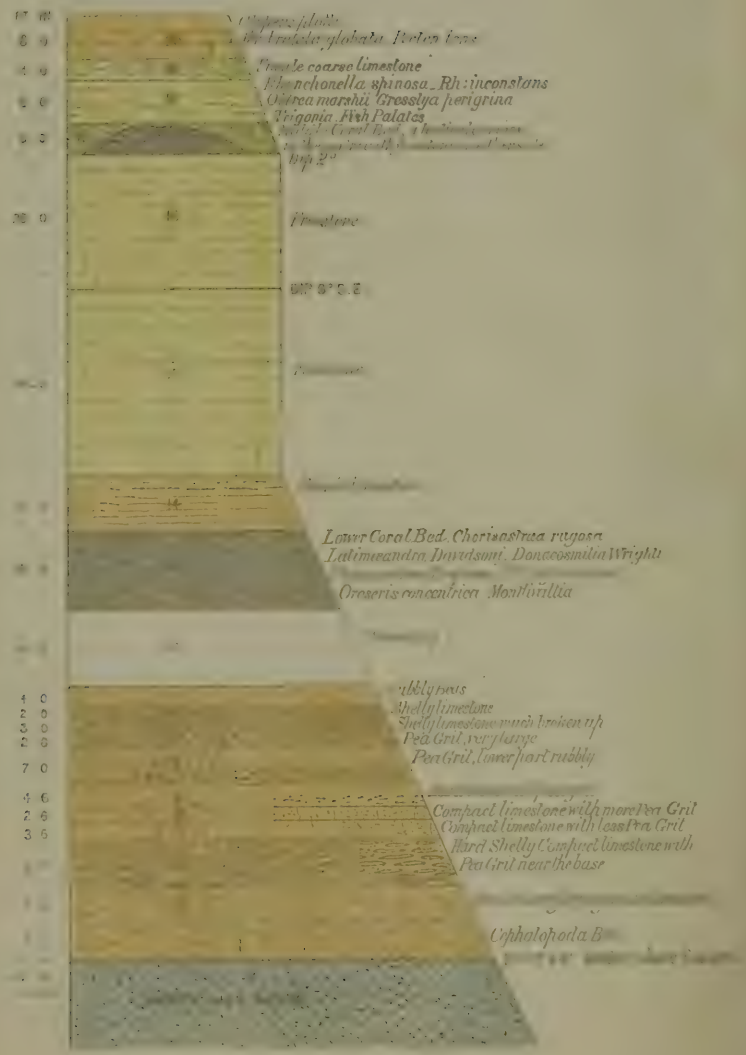
A short distance further on, above Messrs Helps and Foster's lawn, is the bed of 14 feet shewn in the Section as covered up by detritus,* and upon which rests the lower Coral bed of

* Most likely a white limestone, similar to what occurs under the coral bed at Crickley.

W

SECTION

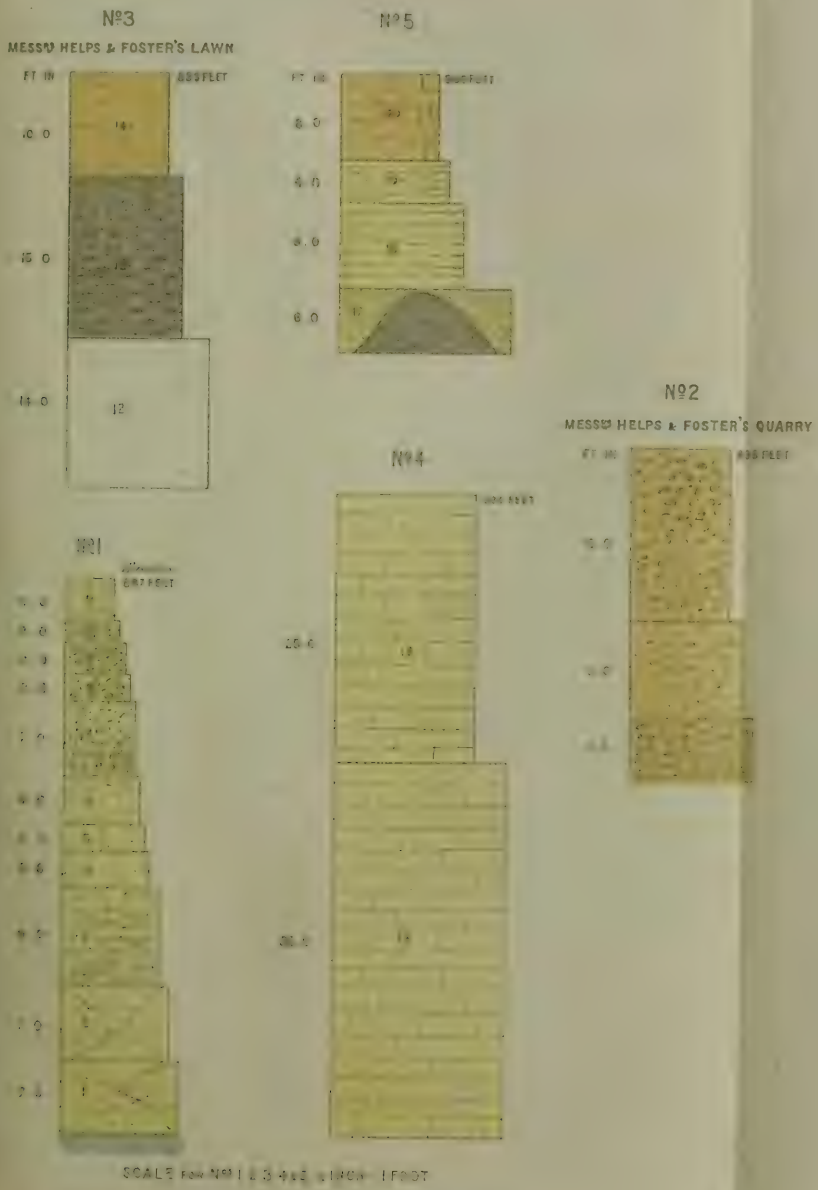
GENERAL SECTION



SCALE ¼INCH = 1 FOOT

LUCY

AT BIRDLIP



15 feet, containing the following Corals, which have been kindly named for me by Mr Tomes:—

Chorisastræa rugosa	Thamnastræa Defranciana
Latimæandra Davidsoni	Oroseris concentrica
Donacosmilia Wrighti	Thecoseris polymorpha
Thamnastræa Terquemi	Dimorpharæa, Lycetti

and an undetermined Montlivaltia

And above this is a Fissile Limestone of 14 feet.

Section 4.

This is a deep quarry of 60 feet of Limestone, with a clear division near the centre; and I have failed to find any fossils, and the beds dip 9 degrees to south-east.

Section 5

Occurs in the plantation, and is not easy of access, and the top of the beds of the Freestone No. 4 are hard and smooth, presenting here a glazed appearance, resembling the action of ice, without, however, any grooving, and the dip is diminished to 2 degrees.

The Coral bed of the Oolite Marl is a lenticular mass, assuming a dome-like form, and the lower part has the appearance of having been forced up, throwing off at the time a kind of bastard Freestone, which is unfossiliferous.

In the numerous visits I have made to this Section, and also after many diligent searches by Messrs Helps and Foster, only one *Terebratula fimbria* has been found, and that was a very imperfect specimen.

Now a most marked change takes place, as the next bed is a very hard stone, full of fossils, mostly much broken up. I was able to identify *Terebratula globata*, *Rhynchonella spinosa*, and inconstant, casts of *Trigonias*, *Tancredia*; large *Oysters*, *Gresslya*, *Fish palates*, &c.

Again is a great lithological difference, as the bed above is a hard coarse, yet fissile Limestone, destitute of organic remains.

Then comes No. 20, the *Clypeus plottii* bed, with *Terebratula globata*, *Pecten lens*, &c., and it extends along the hill, and

is well seen at the top of the road, close to the mile stone, below the inn.

In comparing Birdlip with the important sections in the Stroud area, so well described by Mr Witchell, the principal point of difference is the thinness of the beds above the Cephalopoda, which is represented by seven feet. I am not, however, sure that there is not a bed of about six feet, which intervenes between 2 and 3, and No. 3 perhaps may be regarded as transitional before the Pea Grit is markedly shewn. I have failed to satisfy myself how it is that the Pea Grit appears to be in greater abundance in the partings of the beds, and I have sometimes thought that if the harder parts were more exposed and became disintegrated, it would be more observable in them.

That the Pea Grit should be developed to a greater extent at Birdlip than Stroud, is what might naturally be expected, as Birdlip has a greater resemblance to the sections north of it than those to the south.

The Upper Freestone I believe to be represented by what I have termed the Bastard Freestone, in No. 17, which is shewn to be forced up by the Coral bed of the Oolite Marl.

The scarceness of *Terebratula fimbria* is remarkable, as it is a shell so very abundant in the Oolite Marl of the district; and it is difficult to account for the absence of those very marked beds—the Gryphite and upper Coral bed, both so well exposed at Leckhampton and Stroud.

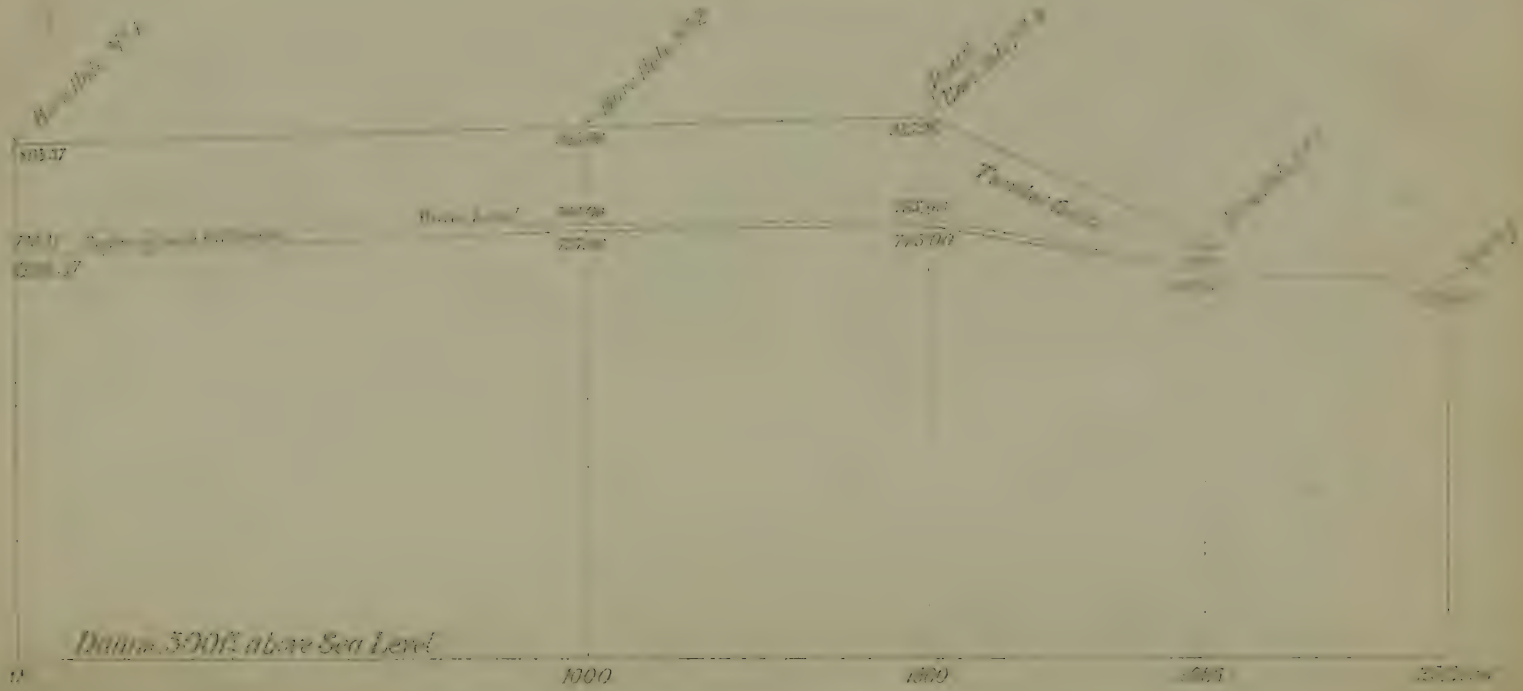
The hard unfossiliferous grit, No. 19, I recognised as the same bed pointed out to me recently by Mr Witchell at Rodborough Hill.

Birdlip shows greater evidences of large fissures and greater dislocations than any section I am acquainted with in the Cotteswolds.

This may arise from two causes—perhaps from both—the one from an unequal contraction and shrinkage of the beds; the other, the Liassic sands having been washed away, causing cracks and faults in the beds upon which they rested.

I hope at some future time to give a supplement, with a full list of the organic remains.

SECTION ON LINE OF TUNNEL



SCALE 300 FEET TO AN INCH. NATURAL

ON A BORING FOR WATER NEAR BIRDLIP

In 1881 the Corporation of Gloucester, under the advice of Mr Bateman, determined to apply to the Local Government Board for power to take water from Birdlip; and a series of borings were made, which I inspected from time to time with Mr Read, the City Surveyor, to whom I beg to express my acknowledgment for the Sections, which I have had enlarged, and much valuable information, which I have availed of in this short Paper.

Mr Bateman's plan was to construct a tunnel three feet six inches high by three feet broad, with a rise of one in 500, and to commence about 240 feet below No. 4 bore hole. The boring No. 1 took place, as shewn in the diagram, 1630 feet from the Painswick road.

Unfortunately a diamond borer was not used, and the hole being made by percussion or stamping, it was impossible to ascertain accurately the character and thickness of the beds passed through before the sands were reached.

The boring commenced in the upper bed of the Inferior Oolite, and I found *Clypeus plottii* on the surface.

Mr Read believes the following Section is approximately correct:—

	ft.	in.
Soil	0	6
Rag Stone	5	6
Freestone	105	0
Oolite Marl	7	0
Freestone and Pea Grit	69	0
Cephalopoda bed	8	0
	195	0

At this depth water was found, and the boring was continued through

Lias Sands	3	0
Sand and Clay	13	0
Sand	1	6
Sand and Clay	91	0
Making a total of	303	6

No. 2 is 1000 feet from No. 1, and with the surface of the ground thirty feet higher; and the water was tapped at 186 feet, and the boring proceeded until it reached 274 feet.

No. 3 boring was undertaken at the suggestion of Mr Bateman, in the hope that a fault existed, which would enable a supply of water to be obtained much nearer to the existing reservoir at Witcombe. On a reference to the map it will be seen it is below the escarpment, and at a lower level by 202 feet than No. 2, and 214 below No. 4.

Water was reached at 45 feet, but the boring was only continued 11 feet, as it was evident, although the sands were there, the sinking was not through beds *in situ*, but a mass of tumbled Oolite.

No. 4 is at the edge of the escarpment, and is 630 feet from No. 2, and at an elevation of 12 feet higher, and 42 feet more than No. 1.

The water was tapped at 190 feet, and at once rose 10 feet: its permanent level. The total boring was 300 feet.

Mr Read informs me that in plotting the above Sections to scale he found that a line drawn through the points in the several bore holes Nos. 1, 2 and 4, at which the water assumed a permanent height, was a continuous straight line, with a flatter gradient than that of the strata passed through; the water was therefore assumed to have a common source.

It is interesting to compare the thickness of the several borings, until the sands were reached, with the Section I have made of the Birdlip escarpment.

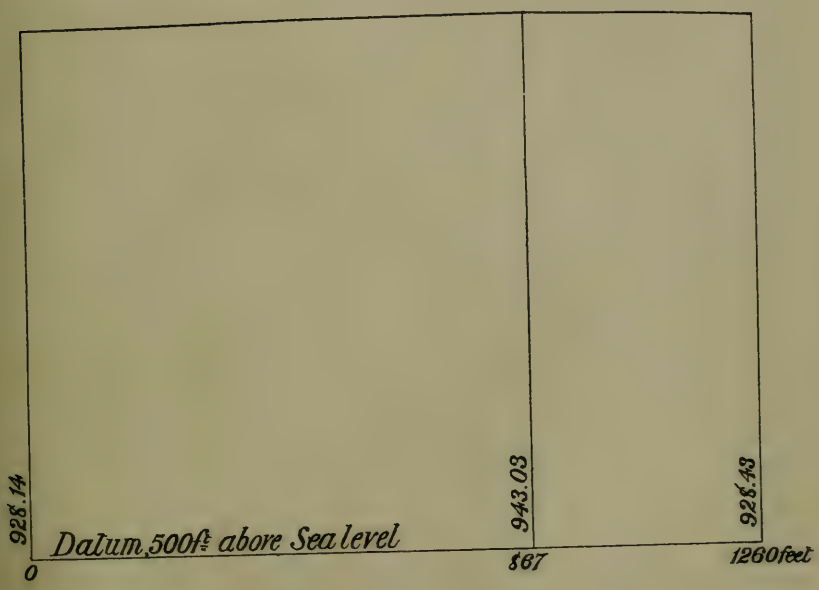
The beds passed through of the latter represent 177 feet, and assuming I am right in adding six feet between No. 2 and 3, would make 183 feet.

Now water was reached at	No. 1	bore-hole	at	195	feet
,, ,, ,,	2	,,		186	,,
,, ,, ,,	4	,,		190	,,

and at the latter assumed a permanent level at 180 feet.

Owing to the opposition to the scheme, and the Local Government Board being uncertain whether they had power to sanction so large an undertaking, the project, at least for a time, has been abandoned.

SECTION ALONG CIRENCESTER ROAD



SCALE 300 FEET TO AN INCH. NATURAL

SECTION AT BIRDLIP WITH LINE

1 Lower Lias Clay and Limestone

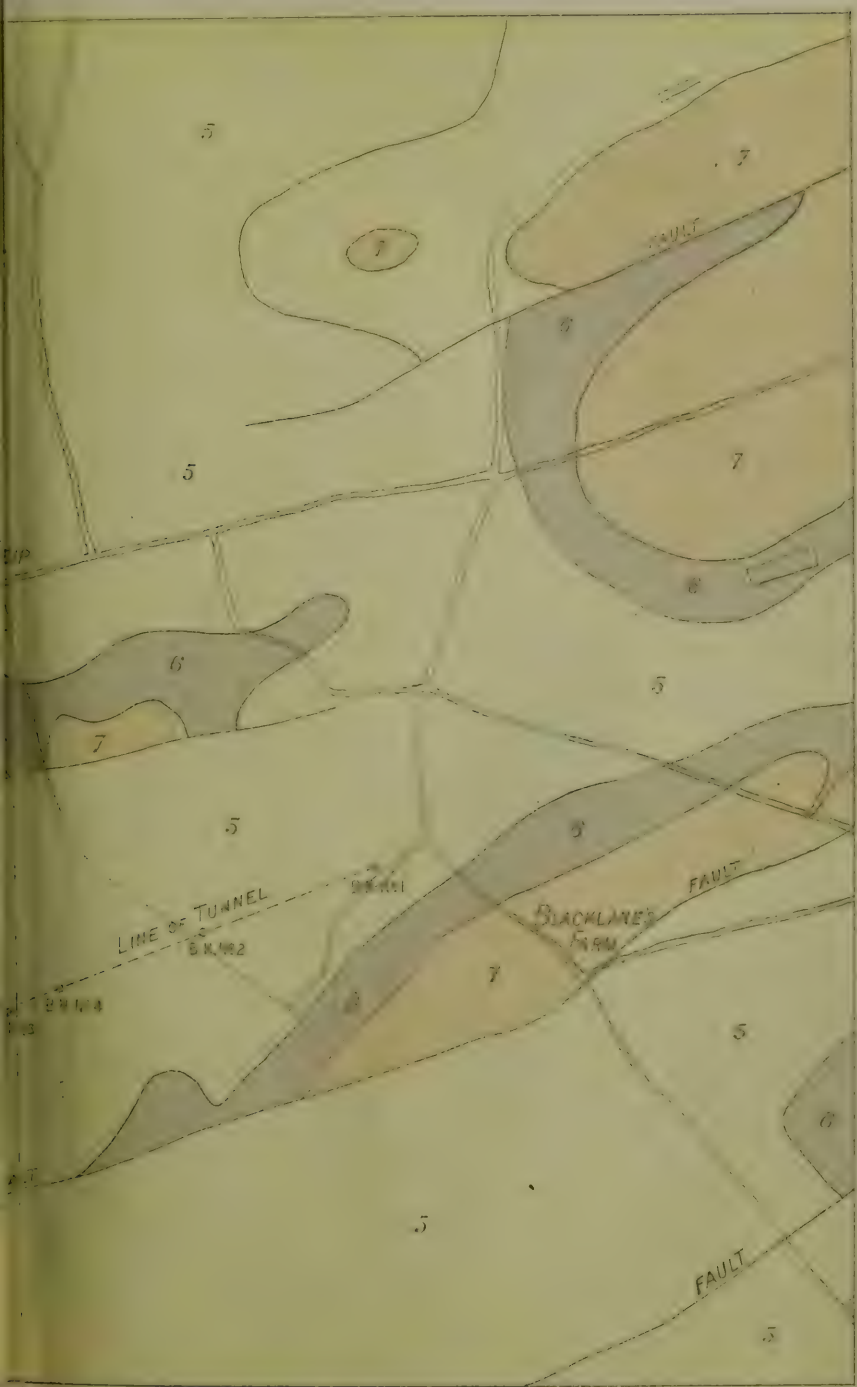
2 Marlstone

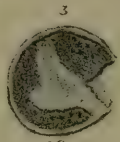
3 Upper Lias Clay

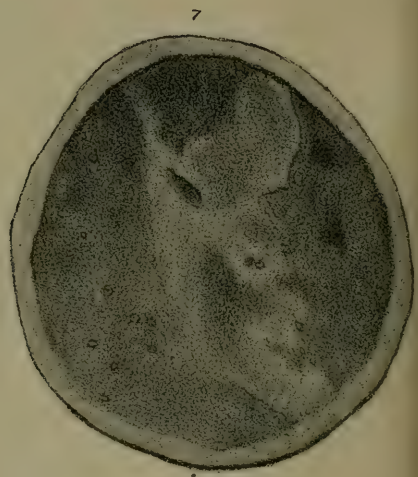
Sand

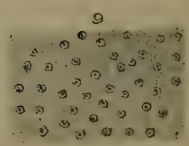
Intrusive

F THE PROPOSED TUNNEL









SPORES OF PLANTS
IN LOWER LIMESTONE SHALES

EXPLANATION OF PLATE.

Figs. Nos. 1, 2, 3, 4, 5.—Spores of Plants from the base of Lower Limestone Shales, Drybrook, Forest of Dean, × 262 diameters.

Figs. Nos. 6, 7.—Spores of Plants from the Black Shales of Ohio, United States, × 262 diameters.

Fig. No. 8.—" A large Spore of *Tasmanites punctatus*, which has been ruptured, × 50 diameters; shows double contour and dotted surface." Copied from Mr E. T. Newton's paper, Geol. Mag. 1875, Plate X, Fig. 2.

Fig. No. 9.—" Portion of *T. punctatus*, Australian White Coal × 250 diameters, to show the dots and extremely fine granulation of the intermediate portion of the surface." Copied from Mr E. T. Newton's paper, Geol. Mag. 1875, Plate X, Fig. 9.

On the Occurrence of Spores of Plants in the Lower Limestone Shales of the Forest of Dean Coalfield, and in the Black Shales of Ohio, United States. By EDWARD WETHERED, F.G.S., F.C.S.

Last year I had the honour of communicating to this Club some observations on the Lower Carboniferous Rocks of the Forest of Dean.* In that Paper I showed that the Devonian Period was brought to a close by a change of conditions which caused a remarkable series of many coloured sandy beds and shales to be deposited, and that these gradually passed up into shales and limestone. I further showed that in parts of Scotland there were similar beds, though of greater thickness, which are known as the Calciferous Series; and I ventured to suggest that the strata which rests on the Old Red Conglomerate, and extends up to the base of the Mountain Limestone in the Forest of Dean, were the equivalents in time of the Scotch beds. There was, however, one physical feature wanting in our own district; it was the occurrence† of seams of coal and bituminous shales in the upper portion of the Calciferous Series of Scotland.

During the examination of the argillaceous bed at the bottom of the Lower Limestone Shales in the Forest of Dean, to which I gave the name of "*Rhynchonella pleurodon* bed," I noticed some small yellow discs, the largest of which measured about ·006 of an inch in diameter. As to what these objects were, I was for a time only able to suggest their being the spores of plants. Some time after the discovery, Dr DAWSON F.R.S., of Montreal, was kind enough to show me some spores which

* "Quart. Jour. Geol. Soc.," Vol. XXXIX, p. 211.

† This feature, however, is confined to certain districts.

occur in the "Black Shales" of Ohio, U.S. On looking at these I at once recognized them as bodies similar to those met with in the *Rhynchonella pleurodon* bed of the Forest of Dean.

That the spores of plants occurred in the "Black Shales" of Ohio was first noticed by Prof. EDWARD ORTON, who referred to them in a Paper read before the American Association for the Advancement of Science, in 1882. I, therefore, wrote to Mr ORTON, who very kindly responded by sending me samples of the material in which they occur. But before I proceed further I must explain the geological position of the Black Shales of Ohio, and they will be found to have an interesting relation to the beds in the Forest of Dean in which the similar spores can be detected.

Above the uppermost Devonian rocks in the State of Ohio comes a development of Shales of very considerable extent. In some parts of the State these deposits are divided into two divisions by a greenish blue shale, known as the "Erie Shales." To the lowest division the name "Huron" has been applied, and to the uppermost "Cleveland." This division appears to be uncertain, and towards the west the Erie Shales disappear. The American Geological Survey have drawn the line between the Devonian and Carboniferous rocks at the Erie Shales, but, owing to this shale not being constant, Professor ORTON points out that the line cannot be drawn, and therefore the strata becomes debatable ground.

Now the "Black Shales" of Ohio are in the same position as the shales at Drybrook, in the Forest of Dean. The *Rhynchonella pleurodon* bed of the latter locality is no doubt of true Carboniferous age,—the occurrence of the shell which gives the name is sufficient to determine that point. But below come other shales, followed by sandy beds, which rest on the Old Red Conglomerate.

The Ohio beds are important as a source of mineral oils; they are bituminous, and contain from eight to twenty-two per cent. of organic matter. To account for mineral oils various theories have been advanced. The vegetable origin has

been suggested by Dr STERRY HUNT,* but at the same time Dr HUNT is disposed to assign the origin in some instances to the decomposition of animal remains. He says—" When, however, it is considered that the lower forms of animals contain considerable proportions of a non-azotized tissue analogous in its composition to that of plants, and that even muscular tissue, plus the elements of water, contain the elements of cellulose and ammonia, it is easy to understand that vegetable and animal remains may, by their slow decomposition, give rise to similar hydrocarbonaceous bodies." Dr NEWBERRY, referring to the same subject, writes†—" Waiting the demonstrative solution of the problem, which patient and exhaustive study will doubtless sometimes furnish, I offer as a possible explanation of the peculiar feature of the Huron Shale the suggestion that its carbon was derived from vegetation which lined the shores and covered the surface of a quiet and almost land-surrounded sea." A similar view has been expressed by Professor ANDREWS;‡ but it was not until the spring of 1881 that any confirmation of the theory was obtained, when Professor ORTON discovered in the Huron Shales, 1000 feet below the surface, " minute translucent discs, resinous in appearance, and unmistakably organic," occurring in great numbers, (Figs. No. 6 and No. 7.) Later on further proof was produced, by the discovery of these bodies in the "Black Shales" of Columbus, Ohio, and finally they were found to occur throughout the "Black Shales."

The Shales in the Forest of Dean are very insignificant compared with those in Ohio. They are at the top interstratified with limestone, and towards the bottom with arenaceous beds; the total thickness would not exceed twenty feet. Spores of plants occur, however, in the Shales (Figs. 1, 3, 4, 5), and though they are not so large as some from America (Figs. 6, 7), there is great similarity between them, and a microscopic section of the beds shows them to be full of decomposed vegetable remains. The Shales are bituminous; a fair average sample

* "Chemical and Geological Essays," p. 179.

† No. I. Vol. "Geol. of Ohio," p. 156.

‡ "Report of Progress of the Ohio Geol. Survey for 1869," p. 65.

gave on analysis 17·15 per cent. of combustible material, 6·85 of which was volatile. I have no doubt that the so called bituminous character of the Shales is due to the vegetable matter contained in them.

As to the spores,—In the Forest of Dean, at Drybrook, two varieties are found, one of which shows triradiate markings (Fig. 2.) The largest of the two varieties do not show these markings, and vary in size from ·004 to ·006 of an inch in diameter. Though much decomposed, some of them still retain the outlines of a wall and, as in the case of Nos. 4 and 5, show minute rings or dots on the surface. I was at first inclined to regard these markings as spores, and the main object as a sporocarp. On examination, however, of a perfect specimen from Ohio, I found the surface covered with what appeared to be spines, and where these seemed to be broken off minute discs, with a black mark in the centre, remained to mark the spot (Fig. No. 6.) Mr E. T. Newton, F.G.S., of H. M. Geological Survey of this country, has described* spores found in Tasmanite and "Australian White Coal." I sent him specimens from the Forest of Dean and from Ohio, and he recognized them as similar bodies to those he had described. Mr Newton, in his description, notices the dots on the surface of the spores, and gives figures of them, two of which I have copied (Figs. Nos. 8, 9.) Mr Newton says, in reference to them, "When examined with a power of about 250 diameters, the dots can be resolved into minute circles $\frac{1}{3000}$ of an inch in diameter, with a still smaller dot in the centre. It may be thought that these dots are comparable to the granules to be seen upon the surface of some of the macrospores of Flemingites; but the study of transverse sections shows at once that these dots are not mere surface-markings, for they can be distinctly traced as minute lines (tubes,) passing from the outer to the inner surface." The second variety of spore from Drybrook I have not seen described. They are much

* "Geol. Mag.," N.S., Decad. 2, Vol. II., p. 337

smaller than those before mentioned, and, as I have said, show triradiate markings.

Next let us consider to what order of vegetation the spores described are allied. Principal Dawson, F.R.S., of Montreal, in a Paper entitled* "Spore Cases in Coal," has mentioned bodies found in shale of the Eran formation, at Kettle Point, Lake Huron, to which he gives the name "*Sporangites.*" Later on Dr Dawson identifies the spores discovered in Ohio by Professor Orton as similar to those found at Kettle Point. Still later, in a Paper read before the American Association for the Advancement of Science, at Montreal, on "*Rhizocarps* in the *Palæozoic* Period," he suggests the possibility of "*Sporangites*" being allied to Rhizocarps, but he leaves the matter open for further investigation. Mr Newton refers, in his Paper to which attention has been called, to the relation of the spores in Tasmanite and Australian White Coal to modern vegetation, and concludes as follows:—"There can be no question as to the Tasmanite sacs being of vegetable origin, although at present we do not know the plant to which they belong: their size and form seem to indicate that they are more nearly allied to Lycapodiaceous macrospores than to anything else." For my own part I prefer to give no opinion beyond that the larger spores from the Forest of Dean belong to a lower order of Cryptogamia.

It may now be well just to summarise the geological position of the strata in which the spores referred to in this Paper occur. The Black Shales of Ohio, as I have said, are debatable ground. The American Geological Survey consider them as part Carboniferous and part Devonian: the Erian formation of Kettle Point, Lake Huron, is looked upon as Upper Devonian. In the Forest of Dean the shales in which the spores occur are in part certainly Carboniferous and in part debatable ground. It is clear, then, that in America and in England, so far as the Forest of Dean Coal-field shows, there must have been a very similar state of conditions—a condition which allowed of the growth of allied vegetation.

* "Amer. Jour. Sci." 1871, and "Canadian Naturalist," N.S., Vol. V.

In conclusion, I may say that I am not aware of the spores described in this Paper having been found in this county before. Further, that the occurrence of bituminous shales at the base of the Carboniferous Limestone in the Forest of Dean adds to the correctness of the view I expressed in my paper last year, namely, that the beds which lie between the Old Red Conglomerate and the Carboniferous Limestone are the equivalents in time of the Calciferous Series of Scotland. It is true we have not seams of coal at the base of the Carboniferous Limestone in the Forest of Dean, but we have vegetable remains and bituminous shales.

On the Occurrence of the Palmate Newt near Stroud.
By C. A. Witchell. *Read by* E. Witchell, *March*, 1884.

In a paper by the late John Jones, which will be found in Vol. III. of the "Transactions," page 157, is a list of the reptilia of this county, in which the Palmate Newt *Lissotriton palmifies* is mentioned on the authority of Mr Baker, of Bridgwater, as occurring in the county of Somerset; but was totally unknown to Mr Jones, and he mentioned it "to call attention to its existence, and to stimulate observation on the part of other members, in order to render our list as perfect as possible."

More than ten years ago I found the Palmate Newt in the ponds near Stroud. It was plentiful in all the smaller ponds, and much more abundant than the common smooth Newt; and on one occasion a bucketful of these Newts was brought to me from a brickyard pool.

It would be interesting to know if Mr Jones had searched for the Palmate Newt near Stroud and had not found it; but had found the common Newt, because it would go far to show that the one was increasing and the other disappearing.

It is said by some Naturalists that the Palmate Newt is a variety of the Common Smooth Newt, *Lissotriton punctatus;* but the differences are considerable. They are: (1) shape of the hind feet, those of the male Palmate being black and completely webbed during the breeding season, the common Newt having always distinct toes. (2) In the shape of the tail, that of the male Palmate ending abruptly with a filament about $\frac{1}{4}$ of an inch long, projecting from the end; while the tail of the Smooth Newt tapers evenly to a point. (3) In the crest, which is not so high as in the Common Newt. (4) In size, the Palmate being the smallest English Newt known.

In colour, it is mottled on the head with gold and olive green. It varies from a yellow to an olive green on the back and sides, and white or yellow beneath. The Common Newt is darker, and of a more leaden colour, and in spring the male is red beneath, which is not the case with the Palmate. (6) In habit, the Palmate takes the water earlier in spring, and leaves it later in autumn than the smooth Newt.

In mild winters the Palmates are to be found in the ponds as early as the 1st of January, and are often killed by the sudden freezing of the surface of the water. The smooth Newt appears about a month later. In point of numbers, in any favourable piece of water near Stroud the Palmates are at least as ten to one of the Smooth Newt.

As regards Newts in general, they may be termed nocturnal, as it is only in the night that they travel on land. It is clear that they are not confined to the immediate neighbourhood of ponds or ditches. When they leave the water in autumn, they take to damp places, and are often found under stones, as mentioned by Mr Jones. The Triton will move up to the tops of the hills, where it sometimes finds very comfortable quarters, often taking possession of an ants' nest, and devouring the ants. I have found young Palmates under stones on dry banks at a considerable distance from any water.

The Tadpole of the Palmate, in common with that of the smooth Newt, often falls a prey to that of the larger Triton; but I have seen a full-grown Triton choked in an endeavour to swallow a full-grown Palmate. The common snake readily eats the Palmate, but avoids the Triton, possibly on account of the irritant secreted in its skin, which would be liberated by the fine piercing teeth of the snake.

On a Remarkable Exposure of the Kellaway's Rock in a recent Cutting near Cirencester. By Professor ALLEN HARKER, F.L.S. *Read* 11*th March*, 1884.

In the valley of the Churn, about 1½ miles S.S.E. of the town of Cirencester, there is a spur of rising ground, which extends almost due North and South, and terminates close to the village of South Cerney. Its greatest elevation is from 35 to 40 feet above the level of the valley; its western flank is abrupt, almost steep, eastward it slopes gently to the lower ground. The new railway from Cirencester to Swindon, has cut through this rising ground in a direction almost at right angles to the trend of the spur, a quarter of a mile from its southern termination. This cutting has exposed the very interesting section which it is the object of this paper to describe—interesting, not only on account of the petrological and palæontological character of the beds which form this hill, but further, because of certain remarkable physical phenomena presented by one bed in particular. At the request of the Club, made on the occasion of its visit to the cutting in June last year, I have brought the matter forward for the discussion of the phenomena alluded to, as they appear to be, so far as I can discover, of a unique character in our local geology. The petrological features of the exposed beds, together with an account of their contained fossils, naturally demand our first attention. The accompanying section is to

PHOTO, BY E. DRURY STOWE, CIRENCESTER

VIEW OF THE CUTTING AT SOUTH CERNEY, JUNE 1883.

(TO ILLUSTRATE PROF. HARKER'S PAPER)

some extent diagrammatic, representing a section at right angles to the cutting, and gives the maximum exposure:—

	ft.	in.
1.—Surface soil	1	6
2.—Drift gravel ... ...varying from	2	9
3.—Clay (Boulder Clay)	3	0
4.—Ferruginous sandstone, fossiliferous	1	0
5.—Shelly Band (Gryphæa dilatata)	0	6
6.—Ferruginous sand (dark brown) fossiliferous ...	3	6
7.—Calcareous sandstone ... ... 5ft. 6in. to	6	0
8.—Yellow sand	8	6
9.—Clay of this was exposed at W. end of cutting	3	6

The drift gravel (2) is the ordinary flat angular gravel of the Cotteswolds: in the valley to the west of the small hill now described, it reaches a depth of six to eight feet, and forms the sub-soil of all the low grounds from Cirencester East and South-Eastward.

The clay (3) is undoubtedly Boulder Clay. It yields only a few broken shells and pebbles.

The beds (4 and 6) appear to be identical in character and composition, but are divided into two by an intervening band (5) of soft shelly marl. This Ferruginous Sandstone (4 and 6) is very dark in colour, soft and crumbling on exposure to the atmosphere. The fossils are all in a very poor condition. They break up readily along with their matrix into a fine shelly sand. On this account we have not been able to make any collection of what would be called Museum specimens, though we have obtained very fine *Belemnites hastata*, *Pholadomya deltoidea*, and *Pecten lens*. Soon after the exposure of the beds my friend, Mr F. Bravender, of Cirencester, whose collection of Kellaway's Rock fossils the Club had the opportunity of inspecting, recognised this Ferruginous Sandstone as being identical with an exposure of the Kellaway's Rock at Ashton Keynes, some miles further south. The beds there, though apparently the same in mineralogical character, and in their fossils, have the advantage of not crumbling on exposure, and Mr Bravender has a large number of fossils collected there, including some species we have not yet recognised at

South Cerney. This rock was first called "Kellaway's Stone" by WILLIAM SMITH; and, in his work "Strata Identified by Organized Fossils, containing prints on coloured paper of the most characteristic specimens in each stratum," 1816, *p.* 23; he says—"The excavations of the Kennet and Avon and Wilts and Berks canals exposed new outcrops of this stone, which I afterwards found on the Thames and Severn Canal, near South Cerney." No doubt he here refers to the cutting which would be made through precisely the same knoll, or spur of rising ground, when the canal which cuts through it not far from our railway cutting, was made. There is no trace now on the banks of the canal of the particular strata, as they have long been covered by soil and vegetation; but, from the measured levels there can be no doubt that the beds extend northwards, beyond the canal. I have evidence of their extension southward to the end of the spur.

The thin shelly band (5) is composed almost entirely of *Gryphœa dilatata*, a characteristic Lamellibranch of the Oxford Clay. These again crumble on exposure, and good specimens are obtained with difficulty.

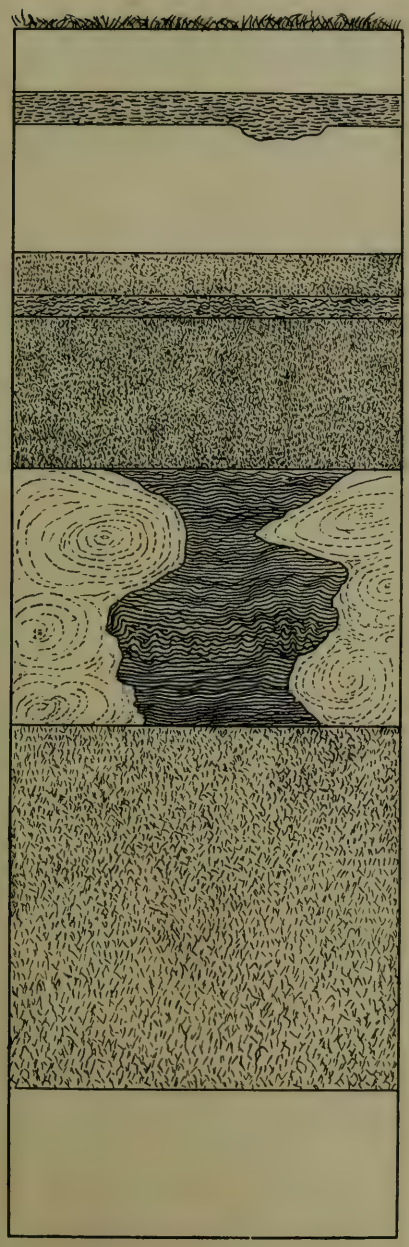
The bed of Calcareous Limestone (6) is the particular stratum of this section to which the attention of students has been specially drawn. The interest of the cutting may be said to centre in this one bed. For that reason I may be excused for giving a more detailed description of it. In physical characters the rock is of a light bluish grey colour, is exceedingly hard and "obstinate," blunting the chisel of the excavators, and resisting any forces but those generated by dynamite or gunpowder. Our colleague, the Rev Dr SMITHE, has kindly made a careful microscopical examination of the rock, and favours me with this report of it:—

"The small piece of Kellaway's Rock was subjected to CORDIER'S process, which method answers very well for simple rocks (see ZIRKEL, *die mikroskop. beschaff.* &c., p. 7). The result comes out thus:—Quartzose grit, containing grains of dirty-coloured quartz, mingled with other grains of hyaline pellucid quartz—both of them are crystallised in the usual

SECTION OF THE KELLAWAY'S ROCK

AT SOUTH CERNEY

$\frac{1}{4}$ inch to the foot



hexagonal forms and sections. These grains are accompanied by smaller comminuted grains of the same quartz, which fill up the interstices, the whole being feebly cemented together with diffused Carbonate of Lime, &c. Occasionally a few specks of iron pyrites occur. The carbonates effervesce with the mineral acids."

This description corresponds to the analysis made of the rock in the Chemical Laboratory of the College here, the result being as follows:—

Sand (silica present as insoluble silicates)	60·74
Lime (Calcium carbonate)...	34·35
Iron (Ferric oxide)	1·94
Manganese and Alumina	·64
Chloride of Sodium	traces
Magnesia (as Carbonate)	traces

It will be seen that the term Calcareous Sandstone, which I have employed is the correct designation of this stone. The rock varies both in colour and in specific gravity in certain defined areas, to be hereafter noticed.

The fact that this stratum is highly fossiliferous and that its fossils are in excellent preservation contributes to the interest it has excited. We have made at the College three separate collections of these fossils, and Mr Bravender has made an extensive one as well. The *Ammonitidae* are very abundant and of all ages, some reaching enormous dimensions. One I measured was 1-ft. 10-in. in greatest diameter. The *Lamellibranchiæ* and *Brachiopoda* are in some cases exceptionally fine. I have one block which consists entirely of Brachiopods in such preservation that in some which are broken open the shelly arm-supports are seen encrusted with minute crystals of calcite, the rest of the interior being still hollow, or only partially filled in. Our collection contains, already identified:—

Cephalopoda

Cosmoceras calloviense	Cosmoceras cordatus
" modiolaris (sub-lævis)	Nautilus hexagonus
" Chamousetti	Belemnites hastatus
" Kœnigi	" Oweni
" Gowerianus	

Lamellibranchiata.

Pholadomyia Phillipsii	Ostrea flabelloides
" deltoidea	Pecten lens
Isocardia mimina	Myacites recurva
Unicardium sulcatum	" (?)
Modiola bipartita	Gresslya peregrina
Gryphæa dilatata	Goniomyia (?)
" bilobata	

Gasteropoda.

Natica punctata	Pleurotomaria depressa

Brachiopoda.

Rhynchonella varians	Waldheimia obovata

The plant remains are equally interesting. Scattered through the whole rock are innumerable pieces of wood, varying in size from small splinters not more than a quarter of an inch long, and no thicker than matches, to large masses, in one case reaching 18 inches in length and three to four inches in the other dimensions. The wood is still in a carbonaceous condition. It is true wood. It crumbles under the action of a penknife, or even the thumb-nail. With some small pieces picked out with a knife I was able to make rough charcoal sketches. This wood is saturated with Carbonate of Lime; on keeping a bit of it on a shelf in my dry laboratory, the Ca CO_3 effloresced out in thin plates, splitting the wood into long thin strips in doing so. I made numerous endeavours to get sections of this wood by rubbing it down, but these were unsuccessful. At length, by soaking in dilute hydrochloric acid, then in alcohol, turpentine, and paraffin, I was able to cut thin sections with a sharp razor (longitudinal and transverse sections were exhibited). I have not seen finer wood sections. The dicolytedonous character of the tissues is apparent, and a minute examination reveals the details of the structure of these tissues. We find abundance of fossil wood in the Forest Marble of the Eastern Cotteswolds; but I have never met with any which so nearly retained its original character—certainly none which cuts so readily with the knife.

Another noteworthy feature of this band of Calcareous Sandstone to which I wish to direct your attention, is its

remarkable concretionary character. This character has been noticed first in the beds at Kellaway, and elsewhere LYELL describes the rock as being *lenticular*. He further speaks of it as an arenaceous limestone, which would hardly apply to the beds at South Cerney.

A clean section of certain portions of the rock shows a series of concentric shells more or less regular in form, the central mass varying in shape from a sphere to prolate spheroids and ellipsoids. These central masses vary very much in size, and the successive eccentric shells vary in thickness, and are sometimes marked off one from another by a different coloration of the stone. I have taken several measurements of these concretionary masses. Here is one of the largest, an elipsoid :—

	ft.	in.
Longest diameter	4	2
Diameter of central mass	2	3
Thickness of first shell...	0	3½
„ „ outer „	0	8

The line of junction between the central mass and the first shell, as well as between that and the outer one, was very clearly indicated by the varying colours of the stones near to the junction, a deep reddish brown line varying from ½ in. to 2 in. in width, evidently coloured by iron, marking it out.

I have had made a determination of the specific gravities of pieces of the rock taken from the centre of one of these blocks, and from the junction of the first shell and its included core. The result shows that the latter is of a higher specific gravity than the central portion, the respective determinations being 2·4 and 2·7. This may be explained, as I have suggested, by the greater amount of iron contained in the dark coloured portions. That the successive layers lying without the central mass are comparable to the layers of a shell is very clearly proved by the fact that on the weathering of broken masses the central core in many places separates out, and the successive shells do the same. Lying about in the cutting were numbers of these regular shaped cores, called "cannon balls" by the workmen, who put aside for me three or four of those which nearly approached a true spherical form. Furthermore, the

hollow interiors of these shells were of frequent occurrence, being revealed constantly after new blastings, the shock loosening and displacing the interior masses.

Another feature of these concretionary masses, which is very significant, is this: that in every case where the central masses were broken up, fossils of one or other of the forms mentioned were found in the centre, apparently forming a nucleus to the mass. Over and over again I tested this by getting the workmen to break up the spheroidal cores they had kept for me, and in every case, without a single exception, one or more Ammonites, or occasionally a pocket of Brachiopods or Lamellibranchs, mingled with pieces of wood, occupied the centre of the block. On each face of the cutting, as one walked along, the same fact was evidenced in scores of examples. When the Club visited the cutting, Dr WRIGHT gave particular attention to this important fact, and had several cores broken up for his inspection. One very characteristic specimen (exhibited) from the centre of such a core, contains several small Ammonites, scores of small splinters of wood, and a colony of Brachiopods, showing the internal structure of the test wherever it has been accidentally broken into.

So far I have confined myself to a description of the observed facts. I now submit an explanation to account for the remarkable features of this bed of Calcareous Sandstone. It is this: That this bed was very rapidly deposited; that it was deposited not far from a land surface; that the *Ammonitidæ* and other animals were entombed alive, or at any rate just newly killed; that the bed rapidly consolidated; that the concretionary character of the masses of rock is due to the decomposition of the organic matter of the entombed animals, the products of decomposition so affecting the enveloping sand and lime, then in a pasty condition, as to lead to an eccentric disposition around the animal nucleus, and the consequent formation of the shell-like layers.*

* Since this paper was read, my friend, Dr SMITHE, has reminded me of a description by JUKES of somewhat similar concretionary masses; and in the 4th edition of JUKES' School Manual of Geology, published recently, p. 143, there is an allusion to similar occurrences.

There is, I think, nothing contrary to our knowledge of physical processes in this hypothesis. It will be seen that the per centage of lime in the rock is high. We have innumerable instances of the formation of calcareous beds in relatively very short periods, due to the precipitation from solution of Carbonate of Lime. I need hardly refer to the classical instance recorded by LYELL of the discovery of a 14th century cannon embedded in a hard calcareous rock at the mouth of the Rhone. Again we know from our text books the effect on beds of minerals which decomposing animal and vegetable matter exerts. The re-arrangement of the mineral constituents of a partially consolidated mass by this means is familiar to the student of Geology. Our colleague Mr E. WETHERED has made a series of observations on this subject. Suppose the large Ammonites and other Mollusca and Brachiopoda were suddenly entombed in a mass of silt consisting of sand and water highly saturated with Carbonate of Lime. They would speedily be killed, and decomposition would set in. The Carbonic Acid (CO_2) of their decaying bodies would dissolve the Carbonate of Lime ($Ca\,CO_3$) in the presence of water, forming the Bicarbonate ($CaH_2\ 2CO_3$,) which would again decompose into Lime Carbonate, water and Carbonic Acid, and the Carbonate of Lime would bind the particles of sand together in the manner in which Dr SMITHE tells us he finds this Kellaway's Rock to be formed. The iron would probably undergo a somewhat comparable decomposition by the action of the Carbonic Acid, and be re-deposited as the Carbonate of Iron. The presence of Iron Pyrites is, we know, a feature of most fossiliferous beds in the Jurassic system.

Other things being equal the diffusion of the gases from the dead animals would proceed at the same rates roughly, solution and re-deposition would follow each other, and the sand would be bound by the calcareous matrix in roughly defined areas, probably comparable to the successive eccentric shells I have endeavoured to describe. I submit this explanation of the phenomena as one which appears to have at least a balance of probabilities in its favour.

One or two isolated observations may be added in support of this view of the mode of origin of the concretionary bed. The fossil remains are in a very perfect condition, the extreme hardness of the stone alone is the cause of our specimens being so much broken. The condition of the tests of the Brachiopoda is especially note-worthy. The absence of Serpulæ on any of the shells is noticeable. In the neighbouring beds of the Cornbrash almost every shell has the tubes of Annelids formed on it, and we know the prevalence of the same organisms throughout the Oolite formations. The occurrence of such a large amount of wood points unmistakeably to the immediate proximity of land, and its condition supports the view that the rock consolidated very quickly.

The bed of sand (8) underlying this Calcareous Sandstone is exceedingly friable, and not at all fossiliferous, nor does it contain any of the wood which is so abundant in the upper bed. It is slightly bound together, probably by Ferric Oxide. The bed of Clay (9) was only exposed at a very short distance at the west end of the cutting, the dip carrying it under the level of the cutting in a few yards. It is true Kellaway Clay, corresponding, I believe, to the clay near Siddington Windmill, which is worked for bricks.

This description of the various strata does not complete the account of the exposure. I have to ask your attention to a phenomenon presented by the cutting which has given it a wide celebrity, and has led to its being visited by many Geologists and by thousands of casual sight-seers, attracted by reports of its singular nature. The interest in it has been intensified by considerations of an economic or financial character.

The contractors or their engineers, in making a preliminary boring, failed to meet in any quantity with the characteristic bed of Calcareous Sandstone (7) to which I have alluded at such length, and this bed was not revealed until the excavations for the cutting had proceeded some considerable length. It was then found that the preliminary boring had passed through what appeared to be a channel in the rock, dividing

it completely on the particular line chosen for the Railway, and this channel was filled with a fine and easily excavated sand, in very marked contrast to the rock, whose removal proved an exceedingly laborious undertaking. The contractors, Messrs Watson, Son, and Watson, have very kindly allowed me to examine the Section of their preliminary boring, which it may be useful to give :—

		ft.	in.
1—Soil and gravel, corresponding to (1 & 2) ...	about	3	0
2—Clay ... 〃 〃 (3)		3	0
3—Sand ... 〃 〃 (4, 5, 6)		5	6
4—Rock (probably upper part of 7)		0	9
5—Sand 〃 〃 〃 (7 & 8)		13	6
6—Clay, corresponding to (9)		3	6

The numbers in brackets correspond, as will be seen, with the numbers in my Section, (*p.* 177.) The fact that this boring only meets with about nine inches of the "*rock*" (No. 4 above,) which is really, as we know, about six feet thick, coupled with the fact that beneath it they found 13 feet of sand, shows that the preliminary boring had only struck a projecting ledge or boss of the Calcareous Sandstone on one side of the channel, and had then continued through the fine sand which fills it up.

As the sand was gradually removed the deep channel which it filled came day by day into fuller view, and its remarkable features were at length completely disclosed. It was first described to me as a collection of gigantic boulders, and so improbable an occurrence sent me off to examine it at once.

It was shortly after its complete excavation that the Club paid a visit to it, and the accompanying photograph was taken a few days after, before the blasting operations had destroyed the main features of the spot. The photograph is taken from near the East end of the cutting, and looks on the northern side westward through the cutting.

The channel varied in breadth from 5—6 feet to 15—18 feet. The photograph shows fairly well the sides of the channel standing out in relief, the rock worn into rounded bosses of varying sizes, while in some cases huge mushroom-shaped masses stand isolated on the underlying sand, but still in continuous line

with the sides of the channel. These were known familiarly to the workmen and the visitors as "boulders." I succeeded in securing the largest isolated one, which is so well shown in the photograph, and it is now in our Botanic Garden at the College. A blast hole had already been bored in it, and it was about to be broken up, when I fortunately visited it. Its weight is about 25 cwts., and its dimensions are 4 ft. 6 in. in diameter and 1 ft. 9 in. in thickness; a section in horizontal plane would be nearly a circle.

The question naturally arises in the mind of the observer, what explanation can be given of these singular conditions? Standing at the point from which the sketch is taken, and looking westward through the cutting, it required but little stretch of the imagination to fancy oneself in the bed of a stream which had hollowed out the channel through which the rails are now laid—the rocky sides of the stream weathered by wind and water into the fantastic rounded bosses of stone which furnish the features of this cutting. Or it might well be that an ancient shore once stretched eastward of the present outcrop, and that the channel is but one of many excavated by the tidal wash of an old Middle Oolite sea.

One or two further observations relating to the sand which filled up the wide channel, as well as the interspaces between the projecting masses of rock may be useful in helping to a solution of the problem.

When the channel was quite cleared out it was very noticeable that this sand was variously coloured in zones of red, brown, or deep yellow, which zones could be traced continuously through the whole length exposed. Between the projecting bosses, in deep recesses, these coloured bands ran uninterruptedly throughout. The sand is remarkably pure. No fossil remains, none of the wood which is so plentiful in the upper rock, were found in it. It contains Chloride of Sodium and traces of Iron, but is otherwise almost absolutely pure sand.

The heavy rains of last spring and summer speedily washed it down from the hollows of the rock, and left standing in still higher relief the prominent bosses seen in the photograph.

There can be little doubt that the rounded character of the sides of the channel is due to the fact that the weathering action, whatever it may have been, followed faithfully the original lines of consolidation of the rock—that is, assuming that the explanation offered of its concretionary character be the correct one. It is for that reason that I ventured on so lengthy a description of the rock itself.

The rock weathers very rapidly, and, doubtless, some of the sand which fills the channel may be derived from the decomposition of the rock itself; but the evidence is, I think, against this being so to any great extent. One of our students living close to Cerney, who has visited the cutting very frequently and regularly, tells me that one of the hardest and most stubborn masses became in a few weeks so much decomposed that pieces of it crumbled in the hand.

Until some favouring circumstances occasion a further exposure of the bed, which, as we have seen, probably underlies all the southern end of the rising ground N.W. of South Cerney, it must remain a matter of conjecture as to whether shore action or the work of a stream excavated for the first time this remarkable channel. Could we find that other such channels break up this bed of rock in our vicinity, we should recognise its resemblance to many a well-known broken rocky shore, daily washed and altered by our own seas, just as I incline to believe the Middle Oolite sea once denuded and fashioned in so remarkable a manner this hard and intractable Kellaway's Rock.

Notes on the Breeding of Fishes, read at a Meeting of the Cotteswold Club, April 1, 1884. By Francis Day, F.L.S., and F.Z.S.

Among the varied subjects pertaining to fisheries and how to lessen the cost of fish to the poorer consumer, by means of increasing the supply, there is none more worthy of a careful consideration than their breeding, and what is favourable to such being successfully carried out. For many causes, some preventible and others apparently insurmountable, combine to press hard upon fishes, more especially on such as have to ascend rivers from the sea in order to attain to a suitable spot where they may deposit their eggs, and so continue their race.

Laws, it is true, have been enacted ostensibly to protect them when breeding, which laws themselves have in many instances become perverted into means for their destruction. Officials have been appointed to see these enactments properly carried out; but some, alas! of these appointments have merged into what might almost be termed sinecures, and no official in the United Kingdom takes an active part in the breeding of the finny tribes. A few of our rivers have been restocked, due to private enterprise, but not from the public purse, and after this has been accomplished, private riparian proprietors have at once sprung into existence, and producing some ancient grant, they have claimed a fishery in a river they have not contributed to replenish. After they have proved their so-called rights, they have rack-rented their fisheries to the highest bidder, while the lessee's only view is to obtain all he is able at the least cost to himself, regardless of seasons or the conditions of fish life. Next comes a protest that the regulations are pressing severely on the hard-working

net fishermen, or those which employ fixed engines,* and in one district, at least, salutary laws have as a consequence been relaxed. Possibly the annihilation of the remainder of our salmon fisheries will be completed when the man who employs fixed engines knows no law but that of his own will, when he is permitted to fish when he likes, where he likes, and how he likes; when the agitator has induced the Legislature to abolish close time and other regulations now but too loosely attended to, and the manufacturer and miner are free to employ our streams to carry away their poisons and their refuse. But the fish themselves have not invariably acted in accordance with official theories and Home Office decisions, as they undoubtedly ought to have done, for they sometimes refuse to ascend fish passes which have received the sanction of the Inspectors of Fisheries, apparently, but of course erroneously, finding the gradient to be too steep.

These and many other important considerations I must defer to a separate paper, restricting myself to-day to the function of "breeding in fishes."

Fishes are diœcious, the sexes being normally present in different individuals. Some are monogamous, as the snake-headed and tropical *Ophiocephalus*, perhaps also our common pike, and many other forms. The majority, however, are polygamous, or perhaps mixogamous when the males and females congregate for breeding purposes, those of the former sex being in excess and several attending on one female, or even changing about to another.

Among most of the cartilaginous fishes, *Chondropterygii*, as sharks, rays, and skates, a congress takes place between the two sexes, the arrangement of the sexual organs being somewhat similar to what obtains among the higher vertebrates. The male organs are mostly compact, of a circumscribed form,

* Fixed engines for fishing were declared a public nuisance at common law and ordered to be destroyed, but, when doing so, certain private rights in them were directed to be respected. All ought to have been at once made away with, the question of compensation being left to subsequent investigation.

and placed far forwards in the abdominal cavity. The *vasa deferentia* communicate with the ureters and terminate upon a cloacal generative organ, external to which on either side, and mostly attached to the anal fins, are the claspers. The female organs are (as in the male) situated far forwards, and remarkable by the modification of the two oviducts, which are not merely distinct from one another, but also from the ureters, while they terminate upon a prominent urethral clitoris, situated between the outlet for the oviducts. The ova are few, and the ovaries occasionally coalescent into one body, are comparatively smaller than in osseous fishes. Different parts of the oviduct may be functionally modified. The ova are fertilised while still contained within the oviduct, where the ova are delayed, and the young may be either occluded in horny cases or even produced alive.

But it is not my purpose to enter upon the breeding of cartilaginous fishes, but to limit my observations to-day to a few notes upon this function as observed in the bony or true fishes (*Teleosteans*), for it is among this sub-class that we find most of our eatable forms.

In the Teleosteans or bony fishes, we observe considerable differances in the form of the male generative organs, but all have one phenomenon in common, which is a great seasonal augmentation in size in such as are not sterile. This organ when arrived at seasonal maturity, is commonly termed the "soft roe" or "milt." It is well known that it is not necessary for fishes to have attained adult size in order to be capable of the reproductive process, the milt being found fully developed, as seen in the parr or young of the salmon. Without detailing the different forms in which these organs exist, it will suffice to remark that when *vasa deferentia* are absent in the males, oviducts are similarly wanting in the females, the parallelism between these organs in the two sexes being, as a rule, very close. When the testis is single so is the ovary. But in some cases, as in the *Salmonidæ*, although *vasa deferentia* are present in the male there are no ducts in the female. In most osseous fishes the ovaries form two elongated sacs, closed anteriorly

but posteriorly continued into a short and wide oviduct, which terminates behind the vent, and mostly before the urethra. The inside of these sacs is more or less lined with the stroma, or a peculiar tissue, within which the ova are developed. In those forms in which the ova are hatched, before extrusion, the stroma does not extend to the hind portion of these sacs, for this locality serves as a sort of uterus, and is furnished while internal incubation is going on with a large albuminous secretion. The products of the reproductive organs may be set free in the peritoneal cavity, finding their exit at the abdominal pore or pores. Or these products may be taken up by the open mouths of the fallopian tubes, or distinct tubes conduct them all the way to their outlet.

The various modifications of the generative organs in true fishes are a simple testis or ovary, but no excretory duct; a partial oviduct united to the ureter, but not continuous with the ovary; or a testis having a long and complex duct distinct from the ureter. Among Teleostean fishes breeding occurs in one of the following ways:—1. The eggs are hatched within the female organs, as seen in the oviparous blenny. 2. As in the majority of these fishes, the eggs having been excluded, are subsequently fertilised by the male, the milt or spermatozoa of the latter being brought into contact in the water with the ova or eggs of the female, when this microscopic body (the spermatozoon) obtains access by a minute orifice, termed the micropyle, into the interior of the ovum. In short in the breeding of osseous fishes the generative organs perform the following functions:—"Semination," "ovulation," "fecundation," and "exclusion," to which in some forms is added that of "fœtation."

Simple as this process would seem to be, there are many interesting questions about it which are still unsolved and require attention. If all fishes' eggs were of one size, the micropyle and spermatozoids identical in all forms, the specific gravity of all ova without variation, and all kinds of fish propagated their species at the same period we should soon arrive at a state of inextricable confusion. There would be

hybrids between salmon and minnows, perches and bullheads, sticklebacks and carps, and were these hybrids to prove fertile, in a comparatively very short space of time all land marks would be obliterated; families, genera, and species would be things of the past. And if this did occur the result could be readily foretold, now small forms obtain sustenance in little as well as in large pieces of water; but were these small forms to merge into the larger, our brooks, our lesser streams, and ponds would no longer be stocked with fish for the size of the stream, and the amount of food would be insufficient to maintain them in health, even were it sufficient to sustain life. And could we hope for a hardy race from young raised under such conditions? Or even were our fishes entirely restricted to our larger rivers, what would occur? Predaceous forms of destroyers, perhaps man himself, would soon diminish and probably annihilate them. I shall presently have to show that deterioration in the size of parent fish may be equivalent to diminution in the size of the offspring, such being Nature's method of preventing the extermination of the race. For decreasing their size will cause them to be less sought after, and it will only be when the larger fish are left for breeders that larger offspring result. In short, when man or other causes afford to fish sufficient protection, then Nature assists in improving the race; when man or other destructive factors greedily kills all they are able, then the breed dwarfs, possibly to prevent its extermination. I will first inquire into what migrations fish undertake, either in the sea or in the fresh waters for the purpose of breeding; and, secondly, whether these migrations can be changed partially or entirely by extraneous causes?

To whichever division fish belong they are generally perceived at the commencement of their breeding season migrating to localities most suitable for the reception of their eggs, and the bringing forth of their young. The majority of marine forms seek banks, or are found nearer in shore or in shallower waters than such as they inhabit at other times. This arrival of gregarious kinds of mature fish occurs when they are ready

for breeding, while their eggs are deposited prior to their leaving, so whether they come to perpetuate their race or seek food for preventing death in each individual of the species, it eventuates that at these periods breeding usually occurs, as may be observed in the herring or in the mackerel. It has been asserted that anadromous forms, or such as live in the sea but deposit their eggs and mostly rear their young in rivers, do not enter these solely for breeding purposes, but that, irritated beyond endurance by some marine parasites, they ascend into fresh waters in order to rid themselves of their tormentors. And in like manner that they leave rivers in order to cause the death of certain fresh-water forms, which give them no rest. Putting aside these far-fetched and theoretical reasons for migration, there is certainly one which is the chief cause or the necessity for the continuation of the species. For this purpose several anadromous forms pass up rivers, sometimes for long distances, and then deposit their ova. Among the most widely distributed of such is the shad, of which we possess two species in the British Isles, both found in the Severn, but up which they now but rarely ascend in numbers to any considerable extent, due to weirs across the river, deficiency of water, or else its poisonous condition. The salmon similarly ascends from the sea to deposit its ova in rivers and streams, and this instinct of migration or necessity for exchanging its locality to a suitable breeding spot may be more or less observed among our trout, charr, and, in fact, all the *Salmonidæ.*

Even some fresh water forms show migratory propensities at the breeding season, but which have mainly to be looked for in larger countries than ours, and where fishes may be observed upon a more extended scale. The mahaseer of India is a barbel (*Barbus,*) but in the east it does not deposit its ova, as a rule, in the rivers of the plains, but migrates during the rains up such as descend from Alpine origin, when turning into a side stream it forms its nursery, having done which it rapidly descends, in order to obviate being cut off by falling waters. Here the young have the head waters to themselves until

the succeeding rains enable them to descend, and at this period fresh parent fish repeat the operation of the previous year.

The season at which breeding occurs varies with the family of fish and the locality. This again is susceptible of further modification, in accordance with the temperature and perhaps composition of the water, the amount of food procurable, and many other local circumstances. Likewise there is some condition in the fish itself, respecting which we know but little, but which plays its part. It is easy to understand that during very cold winters breeding is usually late, which may be partly occasioned by the ova taking longer to hatch, as well as by the parent fish being later depositing its eggs. The period at which the *Salmonidæ* in these isles breed may be roughly estimated (except under exceptional circumstances) at from the commencement of September until the middle of January or February. In 1866 some brook trout eggs were despatched from Hampshire and Buckinghamshire to Tasmania, and the first young reared in the Antipodes formed their redds in July, 1869, or during the coldest season of the year. Sir Humphrey Davey observed in Southern Austria that he found charr just ready to breed in the summer, and he came to the conclusion that the waters at that time must be of a temperature best fitted for the purpose. In Sweden Artedi remarked that the salmon spawned in the middle of the summer. Dr Heysham, in Cumberland, stated that they prefer breeding in the warmer streams, leaving the snow-fed ones until later on. Mr Harvie-Brown, at Loch Gorm. in Sutherlandshire, which is greatly fed by snow water, has taken trout heavy with ova in June and July. But easy as this theory would be in order to explain the different months fishes select for breeding purposes, there exist many exceptions which are still open to discussion. Some rivers are stated to have early and others late breeds of salmon. A correspondent of the *Field*, writing from Devonshire, February 2, 1884, observes, upon having taken out of his trap two pairs of spawning trout, one of the males being nearly 2 lb. in weight. One pair had partly deposited its ova exactly in the same spot

where some of the November fish had formed its redds, and whose eggs were just hatching.

We see the same thing in marine fishes, thus there is not a month around the coasts of Great Britain and Ireland that herrings cannot be found breeding. In the United States the Fishery Department have ascertained that the cod-fish (*Gadus morhua*,) breeds during nine months of the year, namely, from September until May.

Some fishes merely breed once a year, while others do so more frequently. During the breeding season some fishes, as the salmon and the shad in our fresh waters, and the herrings of our seas, appear to decrease the amount of food they consume, or even entirely cease feeding; this may be necessary in some gregarious marine forms, for the following reason: Unless they congregate together at this period there would be great danger in the deposited ova not being fertilised by the milt, for we know that should such not take place in a short time in fresh water they do not become vivified. Should, therefore, fish in this condition have to be roving about in search of food, there would be the possibility that large quantities of eggs would be spoiled, while the forms which produce the greatest number of ova are often those which live in large communities.

Whether breeding occasions any deleterious effects upon fish is capable of more than one answer. Fresh-water forms that produce a moderate number of eggs, or do so gradually, or at more than one period in the year, do not appear to be so much affected as those which deposit large numbers of ova, and complete this process within a short space. As a rule, the result of breeding is that the parent fish goes out of condition, and continues so for a longer or shorter period of time. Herrings, as soon as they are "spent," fall off in condition; the salmon kelt becomes absolutely unwholesome, or else so lean and flabby as to be unsuitable for the table.

Fishes' eggs are of various sizes, and which size is not in relationship to that of the magnitude of the species—thus a codfish has much smaller eggs than a trout, and a common

carp than a charr. While some forms deposit their ova in the sea, others do so in fresh water, which may be stagnant, semi-stagnant, or running. Some eggs are of such a light weight that under certain conditions they may float, as of the cod in the sea, while those of the herring sink; those of the gar fish and its allies are attached by filaments or tendrils to foreign substances, while others are likewise adherent, due to a secretive mucus, as in the lump sucker (*Liparis*,) which deposits its ova on the inside of the valves of dead shells, as a butterfly does on a leaf. While the fresh-water bitterling (*Rhodeus amarus*,) of Continental Europe, is furnished with a long urogenital tube, enabling it to insert its eggs within the valves of the fresh-water mussel.

Among the curious pipe-fishes the eggs are transferred from the female to the male, and in most of the species on the latter sex devolves the duty of hatching them, for which purpose they are deposited up to the period of the evolution of the young in ovigerous sacs variously placed. In the horse-fishes (*Hippocampus*) in pouches under the tail; in our ocean pipe-fishes (*Nerophis*) in rows along the breast and belly. Whether this phenomenon of carrying about the eggs is to protect them from danger, or change the water in which they are kept may be questionable, but as these fishes have several times been hatched in aquaria, it would seem to be for the purpose of protection against foes. Similarly we perceive siluroids (*Arünæ*) of the Eastern and other seas in which the males carry about the ova in their mouths, either continuously or temporarily, and the young may be observed emerging from the ova while it is still in the maw of the male fish. Teleosteans, which have no oviduct, as the *Salmonidæ*, deposit their eggs detached one from the other; but such as possess oviducts often have them surrounded by a viscid secretion, formed from the lining membrane of the oviduct, and agglutinating them in lumps or cords.

Lately Mr Ryder, in the United States, has given some interesting accounts respecting the breeding of the catfish, another form of sheat fish or siluroid, in an aquarium. A pair

were placed in a glass tank, and one morning he saw a mass of ova, about eight inches long, four wide, and from one-half to three-fourths of an inch thick, at the bottom of the aquarium. One of the parents hovered over the eggs, fanning them with its fins, and this fish subsequently proved to be the male. The young hatched in from six to eight days, the female taking no notice either of the eggs or of the young. These eggs, each of which was about one-sixth of an inch in diameter (after it had become distended with water) were adherent, but not enveloped with glutinous material, so that lying loosely, like a pile of shot, they were conveniently placed for aëration by the efforts of the male. An experiment was now tried of taking some of the eggs from the mass, which were placed by themselves, but none hatched, showing that aëration, as carried on by the male, is necessary for their development, and even the young were similarly fanned until they began to feed, which was about the fourteenth day after hatching.

The sticklebacks or pricklebacks of this country, whether marine or fresh-water species, form a nest for the reception of their eggs, which has an entrance on one side, an exit on the other, so that either parent can readily pass through. When the eggs have been safely deposited in the nest, and the necessary fertilisation accomplished, the male takes charge, driving his helpmate off to a safe distance, in order to prevent her making a meal of the ova. Mr Warrington ascertained that in a few days, in the fresh-water species, the nest was more and more opened by the male, evidently owing to the necessity for oxygenation, and he hovered over it, causing a current of water to be propelled across its surface by fanning it with his fins, and after about ten days the nest is destroyed, and minute fry appear, over which the male keeps guard. Some of our marine wrasses of the genus *Crenilabrus* have been observed to construct nests, in which occupation both sexes assist. The river bullhead (*Cottus gobio*) forms a hole in the gravel at the bottom of a stream, and here it keeps guard over its eggs as well as the infant progeny.

In India are several species of the amphibious snake-headed walking-fishes, (*Ophiocephalus*) and the male of the common

striped form (*O. striatus*) constructs a nest with its tail among the vegetation at the sides of the tanks, biting off the ends of the weeds which are growing in the water. Here the ova are deposited, and the male keeps guard. When the little ones come forth it is exceedingly interesting to watch them swimming, generally in two lines, above their parent, which at this time is very fierce, and wages war with all intruders. Other forms belonging to the same genus similarly protect their offspring until old enough to shift for themselves.

Another amphibious fish, the gouramy (*Osphromenus olfax*,) at the Mauritius, acts in a very similar manner, frequenting the sides of the tanks where vegetation is most abundant; it becomes very active during the breeding season, passing in and out of its grassy cover, and in some places thickening it by entangling all trailing shoots, and thus forming a suitable spot for the eggs. Here both parents keep watch until the young appear, and over which they keep guard many days. The hardback (*Callichthys*,) of South America, have likewise been observed to construct nests of leaves or grass, where the ova are placed until hatched, and this spot they carefully watch over. A. Agassiz tells us that while examining the marine products of the Sargasso Sea, Mr Mansfield picked up a round mass of sargassum about the size of two fists, and having the appearance of gulf weed, the branches and leaves of which were closely knit to each other; an elastic thread held the whole together, and which, on being cut, allowed of the mass being opened, the inside of which was found to be full of the eggs of the *Chironectes* fish.

Passing on to single families of fish, or even restricting our investigations to genera, it is interesting to see how even closely related forms differ in the places where they deposit their ova, or the period when they breed. Among the herrings we find that the common herring is breeding in some one or other spot around our coast almost every month in the year; that it deposits from ten to thirty thousand eggs, which are agglutinated together in a mass, and subsiding to the bottom, attach themselves to sea-weeds or other suitable substances: let this nidus for the eggs be trawled away or otherwise destroyed,

and the herrings may permanently, or at least for an indefinite number of years, migrate to a more suitable spot. The sprat gives eggs of about 0·04 in. in diameter, and these likewise sink to the bottom, but not in a mass or covered with adhering substance, as in the herring. The shad of our waters has not yet had this question investigated, but in the United States the Fish Commission find that in the species which is most prized there, *Clupea sapidissima*, the eggs sink, but that they require to be kept in constant motion. Placed in floating boxes, it was observed that they experienced this when a strong current existed, but during slack tides the motion was insufficient, they rested in masses at the bottom of the box, and being very liable to fungus, especially during high temperatures, they became diseased unless stirred up by the hand. Without entering into the composition of the apparatus employed, it was found that for their successful hatching constant motion is necessary. Thus in one genus are forms in which the eggs are agglutinated into a mass, sink, and become attached to suitable fixed objects, in another they simply sink, whereas in a third, although they sink, they require to be kept in constant motion.

If we take another family for investigation, as that of the salmon, trout, and their allies, we find interesting variations. The common smelt (*Osmerus eperlanus*) covers stones, planks, and suitable objects with its adherent ova, which are placed near the level of high water, for the purpose of adhesion. These eggs are furnished with fine filaments on their outer surface, which filaments expand at their distal extremities into the form of a sucker for attachment. The grayling deposits its ova, about April or May, or even earlier, on the gravel at the bottom of a suitable stream; they are not placed in a nest, and appear to be very delicate; their size is rather less than seen in the trout. But the salmon, trout, and charr fan up the gravel, thus forming a trough wherein the ova are deposited, and subsequently the nest, redd or rid, is covered over with the gravel, and here the eggs are left to come to maturity. In all these forms the eggs are heavier than the water in which they

are deposited; still they are treated either by being laid on the bed of the stream or below the gravel, but the pisciculturist has ascertained that this placing them within a bed or nest is not essential to the hatching of any of these forms.

Before passing on from the eggs and how deposited, I must draw attention to a rather curious phenomenon, but too often seen, and which in its most fatal form is known as fish being egg-bound—dying, in fact, unable to void their ova, similarly to fowls unable to lay their eggs, or higher vertebrates which cannot bring forth their young. Some fish, as the herrings, which exude their ova in the open sea, can scarcely be subjected to any extraneous force in order to assist this process, but that such does take place in some fishes has been ascertained. The gold carp (*Carassius auratus*) is one of these forms, and the male (or rather relays of them) have been observed in an aquarium to roll the gravid female like a cask along the bottom of the tank, and to continue this operation without relaxation for a day or two until the wearied female has extruded her ova. The female river lamprey is said to be assisted by the male twisting himself around her, and so expressing the ova and milt, the suctorial mouths of both parents being at this time attached to a stone or other suitable stationary object. While it does not appear unlikely that the female salmon or trout, when forming the redd or nest by lateral strokes of the side and tail portion of the body, is by such active exertion assisting in ridding herself of her eggs. It has been asserted that among these latter fish, when the eggs are ripe there is no power to prevent their escape, but at Howietoun it is found that if the parents are placed in a wooden tank, having smooth sides and bottom, and through which a stream flows, ovulation may be deferred days and even weeks.

But even when fishes' eggs have been deposited it does not follow that it is only necessary, in order that they should hatch, to place them in a hatching box, turn salt water over marine ones and fresh water over those of our streams and lakes. The precautions to be taken by the fishculturist I do not propose alluding to, but certain physical phenomena are very

important. Much capital has been made by the trawlers that they do not injure sea fisheries because cod eggs float. But it has been kept as much as possible in the dark that they only do so under certain conditions of the water in which they are exuded. If a proportion of fresh water becomes mixed with that of the sea so as to alter its usual specific gravity, then the eggs of cod fishes sink. The United States Expedition have found hake with ova, and the young at from 100 to 200 fathoms depth. Some marine fishes' eggs, as that of flat-fish, or *Pluronectidæ*, are recorded to float so long as the water is agitated, but to subside when it is at rest.

Some fishes are sterile from various causes. Thus the common eel, a catadromous form, or one which breeds in the sea but passes its life in fresh waters, is believed only to deposit ova once during its lifetime, and then either dies or returns to the rivers, and is sterile for the remainder of its life. It has been observed that among the *Salmonidæ* sterile forms are seen, but which are believed to be only temporarily so, as for one of two seasons, while, as far as I have had the opportunity of observing, hybrids between species of *Salmonidæ* are sterile.

Fish may also be sterile due to disease. Thus I have seen in a mackerel the oviduct occluded due to disease having set up inflammation and occlusion of the outlet of the oviduct, and thus the preceding years eggs have been retained and formed a large tumour.

Eggs, themselves, of course, may fail in hatching, due to deficiency of fecundation, injurious surroundings, or consequent upon the effects of disease, or the eggs, (as deposited by some hybrids) may be incapable of fertilisation. Fishes' eggs are more or less circular or oval, and of varying colours, being pea green in some sheat fishes or siluroids, while among the *Salmonidæ* they may be coral-red, yellow, or pure white, the herrings usually have a slight pink tinge, while those of the sprat are colourless.

I have already remarked that fishes' eggs before they are fertilised have a small orifice or micropyle into which the spermatozoon enters, but it is evident in sea fishes that if the

egg floats at the surface and the milt is beneath, the chances of fertilisation must be diminished, unless some means to obviate this are in existence. Also that there must exist some mechanical reason for fish eggs to float in some forms, sink in others. Of course, the principal cause which makes eggs subside to the bottom is that their specific gravity is greater than that of the fluid in which they are floating, unless due to some mechanical arrangement (as the presence of filaments) they are attached to foreign substances, when they would sink or swim in accordance with the condition of the body to which they were attached, as the eggs of the marine gar fish; or a fish (as a perch) may have its ova in a band-like state, when it selects rushes, reeds, or grass growing in the water or a piece of wood or other hard substance, against which it (the female) presses itself until one end of the band has become attached, then swimming slowly away the eggs are voided. But sometimes eggs, as of the cod, float in normally saline water, and questions have arisen as to the position of the micropyle. Dr Ransom in 1854 found that in the trout, salmon, and grayling it corresponded to the centre of the germinal pole. Here the formative yelk or germ collects, and having attached to it some oil drops, always floats uppermost. In the Spanish mackerel and some other American forms a single large oil sphere keeps them buoyant, situated at a point immediately opposite the germinal disk, which is constantly inverted or carried on the lower face of the vitellus, thus acting exactly the reverse as observed among the *Salmonidæ*. In the cod no oil drop exists, but the egg is so light that it behaves like the foregoing. It is seen in the cod fisheries that at the period of breeding the egg floats with the micropyle directed downwards, and as a consequence the milters are found to swim lower than the spawners, the milt must consequently ascend. The reverse is observed in the *Salmonidæ*.

It will now be necessary to briefly remark upon the physical changes which fishes' eggs have to undergo prior to their being rendered in a suitable condition to continue the species. If we examine the ovum of an osseous fish under the microscope

we may perceive certain structures, as shown in a magnified form in the diagram on the wall of the egg of the stickleback.

Around the eggs before they are deposited and holding the mass together, is a viscid layer or secretion from the oviduct of the female. This secretion will for some time resist the imbibition of water in the unimpregnated ova, so that they have been observed to remain flaccid at least two and a half hours after immersion. Subsequently it seems to set round the eggs, making them cohere firmly together.

The egg itself may be said externally to have a double cortical layer, the two being divided by an interspace. The outer of these (which is rather thick) may be termed the yelk sac, and is in immediate contact with the second internal or vitelline membrane which surrounds the yelk ball within the yelk sac. The outer membrane of the egg is distinguished in one spot by a number of cup-shaped or mushroom-like processes which cover about one fourth of its surface and mark the germinal pole. In the centre of these small elevations is the micropyle, consisting of a funnel-shaped pit, directed towards the centre of the egg and continued inwards as a narrow tube, with the inner end open. This outer covering of the egg is changed by the imbibition of water from an easily torn membrane into a firm elastic one. The yelk-ball, or that portion surrounded by the vitelline or inner membrane, contains those essential portions of the egg which are subsequently directly transformed into the germ, and into which the micropyle opens. Between the two layers I have described is a space, small in the unimpregnated egg prior to the imbibition of water, but which becomes filled, forming what has been termed the breathing chamber, a space increased probably also in size by a contraction of the yelk. In the stickleback this absorption of water from the outside commences near the micropyle, and gradually extends throughout the chamber, but in most osseous fishes, observes Ransom, water enters freely through the yelk sac, and the breathing chamber may commence simultaneously at all parts of the surface. It is only during this period, when absorption is going on, that

fertilisation can take place, and the spermatozoon obtain access by the micropyle to the germinal spot. When the air-chamber has been filled with water the outer covering of the egg hardens and becomes elastic; it is no longer soft and adhesive,* or, as the Americans term it, "it frees." In this paper it will be unnecessary to enter further into the embryology of osseous fishes, neither will it be required to prove that the elements for respiration must be received through the outer coat from the surrounding water. Here, however, it becomes necessary to point out that as oxygen has to be imbibed through the outer covering of the egg, certain mechanical influences may be at work to prevent this necessary absorption, and so to decrease or altogether cut off the necessary aëration. In some fishes the breathing chamber is very large, swelling the egg to as much as double its original size, and it is evident that were these eggs fixed close together prior to distension, one of two things must occur, either their due expansion must be checked by one pressing against another, or some must give way.

I have already mentioned the eggs of the common smelt, which possess filaments that adhere to contiguous objects, if these filaments are torn off the egg dies. A number placed together prior to imbibition give the appearance under the microscope after the air chamber has become filled that they are honeycombed, which is due to the number of facets the eggs show owing to pressure one against another. Irrespective of injury due to pressure, it is obvious that due aëration of the yelk will be stopped, and as a result death will ensue, a subject I will not pursue further here.

The period which fish eggs take incubating is not only exceedingly varied among those of closely allied species, but it is likewise affected by many extraneous causes. Eggs of sea fishes, as a rule, would appear to hatch in a shorter period than

* Ransom has observed of the eggs of the trout, pressed from the parent into water, stick to the dish for a time, but if first left exposed to the air for a little while, do not. In the stickleback the breathing chamber was complete in five minutes after impregnation, and the funnel of the micropyle was effaced in fourteen minutes.

do those of fresh water forms. The eggs of the herring normally incubate in about three or four weeks, but the escape of the young can be considerably delayed by keeping the water very cold, while its saltness or the reverse exercises no appreciable difference. In the Baltic the German Fish Commissioners found that with the water at 53 degrees the eggs hatched in a week, whereas with the temperature of the water at 38 degrees they took six weeks. In the eggs of the cod fish the American Fish Commissioners observed that hatching took place between the thirteenth and fifteenth days, according to the temperature of the water, while Sars, in Norway, found some to hatch on the eighteenth day. The eggs of the haddock in the United States required an average of nine days, and the shortest period observed was eight days, while those of the coal fish *(Gadus pollachius)*, hatch in four or five days in water of moderate temperature. But if we can find such a difference in the cod family as to the time required for incubation to be from four or five days to six weeks, still greater variations are perceptible among those of the salmon family. At Howietoun the eggs of the smelt *Osmerus eperlanus*) kept in the trout-hatching house took about forty-two days; but, on the water being a little warmer, they came out by the thirty-fourth day. In the same establishment, with the water kept at about 44·1 deg., the brook and other trout took from seventy-one to seventy-two days; the American charr (*Salmo fontinatis*) seventy-three; and the salmon seventy-seven. But the foregoing are subject to wide variations of time (by decreasing the temperature of the water) as of the trout up to 114 days, and the hatching of the salmon has been delayed to the 145th day, or even more, and acting upon this knowledge the eggs of members of the *Salmonidæ* have been transmitted in safety to the Antipodes. The eggs of the grayling (*Thymallus*) normally hatch from the twelfth to the fourteenth day. Here I would draw attention to the various attempts which have been made to prove that salmon can breed in salt water, a proposition advanced by some estuary and shore fishermen, apparently in order to show that there is no necessity to have any restrictive legislation on

salmon fisheries, but that everyone should be permitted to fish as he pleases, while the fish ought to continue their species in the sea, and their young to ascend rivers to be captured.

If we turn to the works of RONDELETIUS and GESNER, who wrote upon the salmon upwards of three and a quarter centuries ago, we find they were upholders of the doctrine that these fish deposited their ova in the sea, WILLUGHBY, in 1686, disputing this; but without giving a history of this controversy, we may well restrict our attention to facts. At the late Fisheries Exhibition, the Commissioner from Canada, Mr WILLMOTT, informed us that salmon can be detained in salt water until ready to be stripped of their ova and milt, which can then be raised in fresh water. But several experiments have all ended in one result, the eggs having died in salt water, as have also all the young; consequently, if salmon from any cause are prevented ascending rivers and have to drop their eggs in saline or brackish water, no young will be hatched, while young placed in brackish or salt water will die.

I remarked, in 1882, that at Sir JAMES GIBSON MAITLAND'S fishponds at Howietoun the Loch Leven variety of trout produced eggs of different sizes in accordance with the parent's age. Thus fish hatched in 1876, or six-year-olds, gave ova, thirty-two of which filled the length of a glass grill, whereas those females which had been hatched in 1875, or seven-year-olds, furnished eggs twenty-seven or twenty-eight of which occupied the same space. Not only does this occur in the Loch Leven variety, but also in the brook trout and the American charr. Even in the common stickleback RANSON has observed that not all the eggs of the same batch have exactly the same dimensions, and still less have those of different individual parents when ripe.

The same phenomenon has been observed in the United States, where the fish commissioner on the M'Cloud river in 1878 remarked that the parent salmon were unusually small, their average weight being under 8lb. This small size was stated to be undoubtedly caused in whole or in part by the fishing at the cannaries of the Sacramento, where the 8in.

meshes of the innumerable drift nets stopped all the larger salmon, but let all the small ones through. The eggs when taken proved to be at least a third smaller than those of most previous years, and the average number of eggs to the fish was about 3,500, against 4,200 in the previous year. In this instance the smaller salmon produced the smaller eggs, but whether the decreased number was not due to the decreased size of the spawners is not evident. Livingston Stone adduces another instance, asserting that American trout or charr living in spring water (which means deficient food) develop smaller eggs than such as reside in brooks. Or poverty in food has the same effect as younger and smaller fish in diminishing the size of ova. This of itself would lead one to suspect that small eggs which may be caused by deficient sustenance in the parent will not produce the largest fry. This difference in the size of fish eggs, which among *Salmonidæ* increase in bulk up to a certain age, must have very important bearings upon their artificial breeding. For the size of the micropyle is in a certain ratio to the size of the eggs, consequently larger eggs of the same species will admit larger spermatozoa than smaller ones. It has been maintained by some fish culturists that very great difficulties, sometimes even amounting to impossibilities, occur in crossing salmon with trout, or rather fecundating the eggs of trout with the milt of the salmon. As this was not found difficult at Howietoun when the eggs were taken from fish some years in the ponds, and which eggs were approaching in size those of the salmon, it appears to me that the difficulty is merely a mechanical one, due to the size of the micropyle, a difficulty which has disappeared at Sir James Gibson Maitland's. Here, I believe is a complete solution of how to obtain crosses between the salmon and the trout.

On November 15th, 1882, 2,000 ova were taken at Howietoun from a Loch Leven trout and fertilised by the milt of an American charr (*Salmo fontinalis*); one in six did not come to maturity, dying during incubation. On the same day 8,000 eggs were removed from an American charr and milted from a

Loch Leven trout, and one in three died, the mortality being double where the size of the ova of the species from which the milt was taken is the larger, thus so far confirming the view that the difficulty in fertilisation is partly a mechanical one. This brings us to the consideration of whether these larger eggs, the produce of older or better fed fishes, will eventuate in an augmented size of the offspring, irrespective of the question of changing the locality they inhabit, or increasing the space or amount of water they reside in. Two sets of Loch Leven trout were stripped on the same day in November, 1882, the parents of one being six-year-olds, and of the other seven-year-olds. The eggs were similarly treated, hatched in the same room, during January and February, 1883, and turned into two ponds of similar size, each 100 feet long, and fed by the same stream. In the upper pond were the progeny of the six-year-old; in the lower, which received the stream after passing through the upper pond, those from the seven-year-old. These ponds we examined on November 29th, 1883, and the fry in the upper appeared to average about 2½in. in length, and in the lower about 3½ ins., showing that the offspring from the older parents had developed the most satisfactory results. Having drawn a net through both ponds and examined those captured, it was evident that the averages were much as they seemed to be when looking into the water. I selected three of the finest fish from each pond, those from the upper averaged a little over 3 ins., while from the lower they were nearly 4 ins., or at nine months of age those which were the progeny of seven-year-old parents were nearly a quarter longer than those which were descended from six-year-old parents. In March, 1884, I again visited these ponds, and found the foregoing results were being still continued.

If the eggs of older fish (up to a certain age) give larger and quicker growing offspring than do those from younger ones, it shows us that fisheries in which only small parents are left as stock may not improbably suffer a deterioration in the race, and this, irrespective of food, may be one cause of how fisheries fall off.

Finally arises the consideration of what benefit to mankind in general are investigations into the breeding of fishes? Here I shall merely enter upon a few, some being now carried out successfully, some experimentally, and, lastly, some theoretically suggested.

In a state of nature salmon and trout eggs are subject to destruction from many foes, and it has been computed that although each female is provided with many hundreds of ova, only about one in nineteen of such as are left in the natural redds ever hatch, and only four or five of these out of 30,000 eggs arrive at maturity and are fit for the table; whereas, taking Howietoun as an instance, it is found that from 90 to 95 per cent. hatch in a well-constructed fish cultural establishment, while the loss among the fry is inconsiderable. Irrespective of this, the young can be turned into the rivers at times when they would be more able to shift for themselves than if they resided there from their earliest days.

Without entering into the reasons, still it is patent to the most casual observer that the interests of the upper riparian proprietors of salmon rivers are not always in agreement with those of the estuaries and lower waters. The former consider the fish are reared in their territory, but that the produce is almost exclusively captured at or near the mouths of the rivers. The lower proprietors in some places, believing that the upper proprietors are helpless, do not always listen to their complaints in an amicable manner, considering themselves masters of the situation. But as a knowledge of fish culture extends, it will be found that, did they know it, exactly the reverse is the case. The upper proprietors might obtain such splendid breeds of trout for their rivers that they would not care to continue preserving the salmon. Or they might introduce a land-locked salmon, or one which does not descend to the sea, but passes all its life in fresh water. Or hybrids between the salmon and trout might be sterile, and not take on migratory propensities.

I have shown how, by selection of parents, larger and more rapidly growing trout can be raised, and these fish, provided they can obtain sufficient food, attain to a size now but seldom seen, but when observed being termed *Salmo ferox*. Thus eggs

sent from small brook trout in Hampshire and Buckinghamshire to New Zealand, have developed into 20 lb. and 30 lb. fish. But to obtain these fine breeds, great care must be taken in keeping the parent fish in suitable ponds; if breeders of different years can intermix, then the benefits of age will be lost. Thus it is the finest forms come from seven or eight year old parents, as has been ascertained at Howietoun, where the young, the progeny of such, are now being kept to be breeders in their turn, and it does not seem an unreasonable expectation to see in a few years such a semi-domesticated breed as these islands have never witnessed; and all this due to the enterprise of a single energetic private individual.

Then there are the so-termed land-locked salmon, which might prove invaluable to upper riparian proprietors, or those who possess inland lakes, or where descent to the sea is rendered impossible from any cause. In Maine, in the United States, there is found a variety of the salmon which has taken on a lake-life, and never descends to the sea; many of the eggs were sent over last year to this country, and the young reared from them were exhibited in the Fisheries Exhibition. The Canadian Commissioner observed that in some of the rivers of the Dominion of Canada the same variety obtains. From Lake Wenern, in Sweden, a few of the identical land-locked form were received at the Fisheries Exhibition, some of which weighed as much as 15 lb. All these forms are merely varieties of the common salmon (*Salmo salar*,) that has altered its conditions of life. It has been asserted by some so-called authorities on fish that no salmon in our country has ever developed ova without first descending to the sea. Here, again, facts at Howietoun entirely disprove this assertion. Some young salmon were hatched in March, 1881, and in December, 1883, while still in the ponds, some females were found with ova. These, being bred from, will form the nucleus for a land-locked race, and which, after one or two generations, will be similar in all respects to those of Maine and Lake Wenern. As some (in Canada) are found in the rivers, there does not seem to be any reason why the same results might not be obtained in this country.

Then we have hybrids between the salmon and the trout. Here it seems probable that the offspring will be sterile, at least such has been found to be the case in the few instances examined at Howietoun. Without detailing all the experiments which are still in progress, I will advert to a few results which have been ascertained. In December, 1881, 20,000 Loch Leven trout eggs were fertilised by salmon milt, and on March 13, 1884, 212 fish, the largest six being each above 10 ins. long, were transferred to the Octagon Pond at Craigend. In November, 1883, 4,500 eggs of the Loch Leven trout were milted from a parr salmon which had been raised at Howietoun. Most of the eggs hatched, but all the young were deficient in vitality, and suffering from dropsy of the umbilical vesicle. At the same time 3,695 eggs of an American charr (*S. fontinalis*,) were milted from another salmon parr, but only a few hatched, seven being alive on my visit in March. A charr, it must be remembered, is further removed in relationship from the salmon than is a trout, and has smaller eggs. The next experiment was made with 1,000 brook trout eggs, milted from a salmon parr which had been dead some hours, but none of the eggs were vivified, another proof of the deficiency of power in the milt of such young parents.

In November, 1882, Loch Leven trout eggs were milted from American charr, and American charr eggs were milted from Loch Leven trout. The result has been a very large percentage of monstrosities, deformities, and deaths, and although between 200 and 300 are still alive, the cross does not appear to be satisfactory.

In November, 1882, 9,000 eggs of an American charr were milted from a Scotch charr, and neither monstrosities nor deformities resulted; ninety-one fine little fish thus bred are at Howietoun. In November, 1883, this cross was again made, and about 500 alevins are alive and well; and in December more were laid down, and upwards of 100 young are present. Appearances would go to the conclusion that these two forms of charr are merely varieties of one species, differentiated in colour and by the localities where they live. In short, young

mothers or young fathers would seem to give eggs and milt which are more deficient in vital properties than such as are obtained from more mature parents. Different species of *Salmonidæ* may be crossed, but experience has yet to ascertain if the progeny will be sterile or fertile, local or anadromous in their habits. If sterile, and no longer migratory in their instincts, will they be in season all the year round? Could the fishculturist raise a non-migratory sterile form what an addition it would be to the lake fisheries, also to the upper waters of our rivers, with, of course, the drawback that the numbers would have to be occasionally replenished.

So far as I am aware, the Fishery Department of the United Kingdom—a department which does not carry out experiments among our fresh-water fishes, nor investigations respecting those of the sea, gives no assistance and affords no aid. It is left to a single public-spirited individual to effect everything at his sole cost, and which he most efficiently does, regardless of trouble and expense.

The United States, which possesses a competent fishery establishment, have demonstrated how marine fishes can be artificially hatched as readily as those of the fresh waters; and if our fisheries are to supply our growing populations with food, such will probably have to be effected not by legalising the massacre of the young of in-shore forms, unless to counterbalance such destruction artificial culture is brought into exercise, and man replenishes with one hand the waste which he is occasioning with the other.

Section of a Well Sinking at the Island, Gloucester, by Messrs Robertson & Co., and some Remarks upon the Thickness of the Lower Lias at Gloucester and the Neighbourhood. By W. C. Lucy, F.G.S. *Read Feb. 6th,* 1884.

Last year my friends Messrs Robertson, consulted me as to the probable depth water could be found by sinking a well, as they were desirous of having an independent supply for the use of their brewery.

After much consideration, it appeared to me that the Rhætic beds would be reached at a depth of not exceeding 200 feet, in which water in fair abundance might be looked for.

As the test of boring has shewn my error, I think it will be interesting to the Members of the Club to have recorded a section of the boring, which reached 350 feet, without finding water, or the Rhætics; and afterwards the ground upon which I formed my opinion, with a probable explanation of the cause of my mistake; and then to offer some remarks upon what seems to me to be the position of the Lias at and near Gloucester.

The boring was commenced on the 9th January, 1883, with an augur, a well having previously been sunk nine feet; and, as the clay was soft, it was used for a depth of 90 feet.

The chisel then became necessary, and was employed throughout the remainder of the work.

The size of the boring was sufficient to admit of the introduction of an iron lining pipe, with a seven-inch internal diameter, until 177 feet was reached, when a smaller pipe of 5½ inches was used.

From 90 to 165 feet the clay varied in nature, being alternately soft and hard; but, as will be seen in the section at 170 to 175 feet, hard stone occurred, with, I think, some tough clay, which much retarded progress, and only 11 inches of work was done in the day—the 17th February.

It was not until the 24th, when the boring was 200 feet, that the clay which came up was carefully examined.

On the 2nd of March I became very anxious, as the depth had reached 223 feet, and I sent over a few small but imperfect shells to Dr Wright, with a piece of Pyrites, but he wrote to me that he was unable to give an opinion from such fragmentary specimens.

At 228 feet part of an Ammonite was found, followed by some broken *Gryphæa incurva*, and at 243 feet I took Mr De Rance, of the Geological Survey, who was at Gloucester about the supply of water which the Corporation proposed to take from Birdlip, but he could not throw any light upon the exact position of the beds.

At 259 feet I confess I felt quite perplexed, and wrote to Dr Wright, who kindly came over on the 14th March, by which day the boring had been sunk to 264 feet.

We carefully examined the shells, which apparently were small *Cardiums* and *Cerithiums*, and he thought the *Avicula Contorta* zone was reached.

On the 28th, 288 feet depth, I was satisfied the boring was well in the Rhætic Beds. Dr Wright came over on the 30th, depth 294 feet, and, from the spoil and small shells, we were both of opinion that the boring was well in the Rhætic.

When I visited the work on the 17th of April, on looking at the spoil and the shells found, I was much surprised: instead of the beds being Rhætic, they appeared to me to be the lower beds of the *Bucklandi* zone.

Dr Wright came again on the 21st April, the depth then being 341 feet; and he was of opinion the boring was in the *Bucklandi* beds, or might be in even the *Turneri*.

The boring had reached 350½ feet on the 28th April, when it was stopped.

Having occasion to go to town about this time, I took with me some shells, which had been carefully put aside by Messrs Robertson, which I shewed to Mr Etheridge, and he named the following:—

At 267	feet	—Astarte and Cerithium
" 281/3	"	—Astarte, Cyprina, Avicula inæquivalis, Gryphites
" 292/8	"	—Ammonites semi-costatus
" 340/6	"	—Very hard indurated bed
" 316	"	—Lima and Avicula, tough bed
" 323/29	"	—Ammonites semi-costatus, Gryphites.
" 340	"	—Cerithium, Pleuromya
" 344	"	—Tornatella or Cylindrites

The finding of this latter shell satisfied Mr Etheridge as to the position of the boring, as it belongs to the lower bed of the *Bucklandi*, and he expressed himself confident that if the boring were continued, in 80 feet the Rhætics would be passed through, and he urged it should be resumed; but, after what had taken place, I did not feel justified in advising Messrs Robertson to do so.

I will now state briefly my reasons for believing that the Rhætic beds were nearer the surface, and the basis upon which I formed that opinion.

If we look at the map it will be observed that the Lower Lias on the other side of the Severn varies from one to two miles from the alluvium meadows to where it rests against the new Red Sandstone. That from the Island at Gloucester to Highnam Green, where, when a well was sunk a few years ago to a depth of about 20 feet, the bone bed of the Rhætic was passed through (as the late Mr John Jones and myself saw.)

That the Rhætic beds come up at Wainlode, four miles from Gloucester, on this side of the Severn, and also three miles south, at Elmore.

At Wainlode the *Ostrea* bed is 33 feet above the Tea-Green Marls, and at Westbury 35 feet, with a dip of 3 degrees.

In a field near to Mr Charles Walker's, at Norton Court, about three quarters of a mile from Wainlode, the *Planorbis*

beds are met with, as far as I could estimate, at 70 feet above the sea, and at Lassington, 2¾ miles distant from the boring, the Rhætic beds occur.

These several places and heights shew a general concurrence in the position of the beds.

My impression certainly was that—considering as the boring was less than two miles from Highnam Green, and that north and south of Gloucester the Rhætic beds were brought to the surface, and that the *Bucklandi* beds were in the cutting of the South Wales Railway, just after leaving Highnam; and that I had, at a considerable elevation at Maisemore, found *Lima gigantea*—I thought the upheaval which brought the new Red Sandstone against the Lias, exposing the Rhætics, would probably have affected the bottom beds of the Lias at Gloucester, and brought them nearer the surface.

Lately, in making the railway to Ledbury, at Over, near Gloucester, in the cutting there, slightly exceeding half a mile from the boring, *Ammonites stellaris* has been found; and about 1¾ miles further, at Lassington, the *Planorbis* beds are exposed, and close to is the White Lias, containing *Monotis decussata*, forced up at an acute angle—the paper shales of Westbury being absent—and resting on the Tea-Green Marls.

Ammonites stellaris was found some years since, in forming a wharf in the Gloucester and Berkeley Canal, at Hempsted, at a depth of about eight feet below the level of the water.

There is a difference in level at Over compared with the Canal of 25 feet, which is about the normal dip of the Lias and Oolite, and therefore this area was outside the upheaval referred to; but it is evident that its effect was considerable at Lassington, as the Rhætic beds occur there, and at an elevation of 26 feet higher than at Over.

The result of the boring, although very unsatisfactory to my friends Messrs Robertson, is extremely interesting and instructive geologically.

It clearly shews—from the depth of 350½ feet having been reached—that the Lower Lias is most likely at this point 400 feet thick.

There is no positive evidence as to what the upper bed is; but, as far as I can now judge, it was the top of the *Bucklandi* beds, or the lower beds of the *Turneri* zone.

The beds of the Lower Lias above are difficult to trace, but at Brookthorpe, four miles from Gloucester, at an elevation of 150 feet above the boring, the lower bed of the Middle Lias occurs.

I think we may, therefore, assume that the depth of the Lower Lias is about 550 feet.

Mr Hull, in his memoir of Sheet 44, states that under Cheltenham the Lower Lias is supposed to be 600 feet; but does not give any information as to how the thickness is arrived at; and that southward, towards Bristol, the thickness is only 300 to 400 feet.

The boring has, I believe, added much to our knowledge of the Lower Lias in this neighbourhood, and which will be of advantage to future observers.

Now it may not unnaturally be asked, How it was that Dr Wright and myself were unable to determine the position of the beds long before the boring ceased, and so have saved Messrs Robertson considerable expense?

To this I would remark that there is always much difficulty in ascertaining where shells come from in a boring, more particularly when only a small-sized augur is used.

The pieces of *Gryphæa* we thought might have fallen in from the beds above, and we felt justified in thinking such was the case, as the character of the small shells brought up in the core shewed so marked a resemblance to those occurring in the *Avicula contorta* series, and which probably have a wider range than is generally supposed.

The moral, perhaps, to be drawn is this:—That whenever you are near to a great line of disturbance which, in this case, Professor Phillips was of opinion extended for 120 miles, from Flintshire into Somersetshire, and probably at least the major part took place at the close of the Permian; and as there is unquestionable evidence of a considerable upheaval occurring after the Lias was deposited, as is shown at Purton, the greatest

care is needed in forming an hypothetical opinion under such conditions.

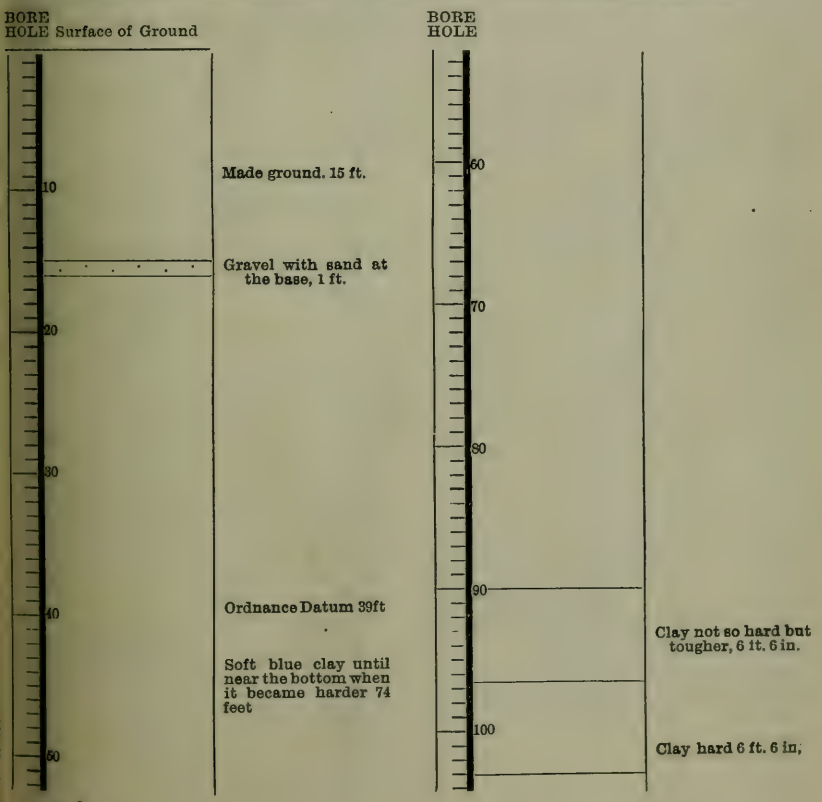
It is extremely difficult to realise how great the dislocation must have been in this neighbourhood. To the west are the older formations, and all eastward are the secondary rocks, under which doubtless are the rocks of the west, which have probably been much depressed by a great fault, as there is every reason to believe that, if the Lias in the plain were pierced to a sufficient depth, the older formations would be found, as in the neighbourhood of London, at Kentish Town, and recently at Richmond, where a well has been sunk 1,310 feet—150 feet lower than that of any well within the London basin; and, strange to say, no Lias was met with, or Inferior Oolite; a bed, 87½ feet thick, was passed through, supposed to be Great Oolite.

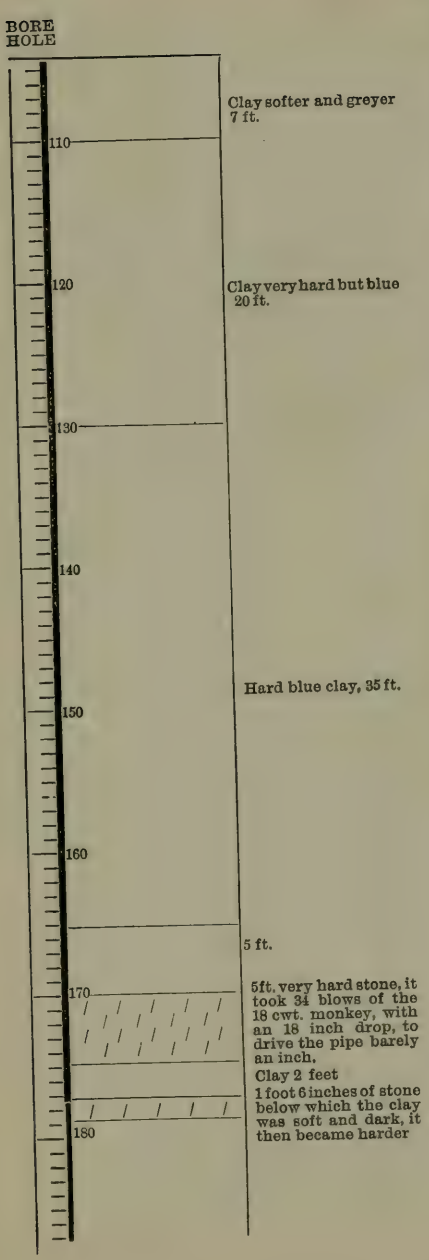
SECTION OF A WELL BORING

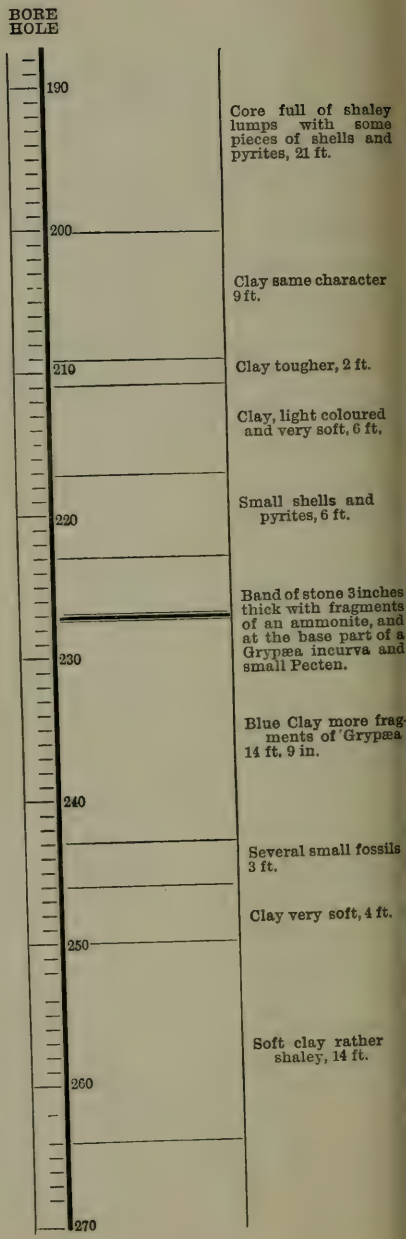
MADE AT MESSRS ROBERTSON'S BREWERY,

WESTGATE STREET, GLOUCESTER

Bore Hole 7 inch diameter to 177 feet, from 177 feet to 350 5½ inch diameter




BORE HOLE
110
120
130
140
150
160
170
180
Clay softer and greyer 7 ft.
Clay very hard but blue 20 ft.
Hard blue clay, 35 ft.
5 ft.
5ft. very hard stone, it took 34 blows of the 18 cwt. monkey, with an 18 inch drop, to drive the pipe barely an inch.
Clay 2 feet
1 foot 6 inches of stone below which the clay was soft and dark, it then became harder


BORE HOLE
190
200
210
220
230
240
250
260
270
Core full of shaley lumps with some pieces of shells and pyrites, 21 ft.
Clay same character 9 ft.
Clay tougher, 2 ft.
Clay, light coloured and very soft, 6 ft.
Small shells and pyrites, 6 ft.
Band of stone 3 inches thick with fragments of an ammonite, and at the base part of a Grypæa incurva and small Pecten.
Blue Clay more fragments of Grypæa 14 ft. 9 in.
Several small fossils 3 ft.
Clay very soft, 4 ft.
Soft clay rather shaley, 14 ft.

BORE HOLE

280 — Shaley clay, Astarte, Cerithium, cyprina, avicula, inœquivalvis gryphite, 24 ft.

290 — Ammonite semicostatus, 6 ft.

10 inches of very hard light grey clay, it then became much softer 7 ft.

300 — 5 ft.

2 feet 2 inches of grey stone.

Very hard clay 4 ft.

310

BORE HOLE

Clay softer, broken gryphæa, ammonite 2 ft.

Clay soft with a hard vein in it Lima avicula 2 ft. 6 in.

320 — Soft Clay without fossils, ammonite semicostatus, gryphite 12 ft. 6 in.

330 — Clay, very soft, without fossils, 8 ft.

Hard Clay, Cerithium, Pleuromya 3 ft.

340 — Very hard Clay, 1 ft.

Hard clay, Tornatella or Cylindrites 9 ft. 6 in.

350

TOTAL DEPTH OF BORING 350 FEET 6 INCHES.

PROCEEDINGS

OF THE

Cotteswold Naturalists' FIELD CLUB,

For 1884—1885.

President:

SIR WILLIAM V. GUISE, BART., F.L.S., F.G.S.

Vice-Presidents:

T. B. LL. BAKER, ESQ., F.S.S.

WILLIAM C. LUCY, F.G.S.

Honorary Secretary:

WILLIAM HENRY PAINE, M.D., F.G.S., F.M.S.

Honorary Treasurer:

EDWIN WITCHELL, F.G.S.

Contents:

JOHN BELLOWS, GLO'STER.

Address to the Cotteswold Naturalists' Field Club, read by the President, Sir WILLIAM V. GUISE, BART, F.L.S., F.G.S., *at Gloucester, on Wednesday, 22nd April, 1885.*

GENTLEMEN,—

The return of Spring calls us together again to take a review of the past, and to arrange our plans for the future. I am glad on the present occasion, as heretofore, to congratulate the Club on the work accomplished—on the financial condition and general prosperity of the Society. The numbers of the Club are well maintained, but death has been busy amongst us, and has removed two of our original members, whose names have been associated with our Transactions from the date of our formation—I allude to the late Professor BUCKMAN and Dr WRIGHT. Professor BUCKMAN acted as secretary to the Club under the Presidency of Mr BARWICK BAKER. On reference to the Club records I find that JAMES BUCKMAN was elected a member of the Club on the 18th August, 1846. For many years he was a frequent contributor to the Transactions of the Club. He ceased to be Secretary in 1859, and shortly afterwards he retired into Dorsetshire, where he aided in the formation of the Dorsetshire Natural History Society, of which he continued to be Secretary until his death, which occurred in November last. For many years he had ceased to attend our meetings or to contribute to our Transactions, which caused his loss to be less felt than it would have been at an earlier period of his career. Not so, however, of his great colleague, Dr WRIGHT, whose loss to the Club may be said to be irreparable. Open a volume of our Transactions where you will and you will find records of the Doctor's keen intelligence, acute powers of observation, clearness of intellect, and perspicuity of expression. The records of the Club bear evidence of the Doctor's

zeal in the pursuit of science, and of his skill as a Palæontologist, a skill which, making its first mark in the Transactions of the Cotteswold Club, blossomed forth into those splendid monographs published by the Palæontographical Society, with which the Doctor's name will be honorably associated through all time. He was a strong man, and held to his opinions strenuously; he was vehement when aroused, and an able and eloquent disputant, but there was no bitterness in his heart, which was ever warm and genial. His memory will ever be cherished by his friends, and by the members of the Cotteswold Club, with reverence for his powerful intellect, and with affection for his memory. He died on November 17th, 1884, and lies buried, by the side of his wife, in the new Cemetery at Cheltenham.

Besides these we have lost by death Dr Washbourn, M.D., and Mr John Middleton; while Dr Wood and Mr Edward Cripps have retired. The Club now reckons eighty-seven ordinary members, six honorary members, and five officers—total ninety-eight.

The financial statement by the Treasurer, Mr Witchell, shows that we have in the bank £70, to which when the incoming subscriptions are added, will shew a very handsome balance to our credit.

I will now proceed to read the record of the proceedings of the Club during the past season.

THE ANNUAL MEETING OF THE CLUB

was held at the Bell Hotel, Gloucester, on Wednesday the 23rd of April, 1884. The Chair was taken at 2 p.m., when the President read his Address, after which the election of officers was proceeded with. Sir William Guise was again elected President, with T. B. Ll. Baker, Dr Wright, F.R.S., and W. C. Lucy, F.G.S., Vice-Presidents; Dr Paine, M.D., Honorary Secretary, and E. Witchell, F.G.S., Honorary Treasurer. The Treasurer's accounts showed a balance of about £100, besides considerable arrears yet to be got in. The favorable condition of the finances brought up again the question of

re-printing some of the earlier portions of the Society's Transactions, which it was determined to proceed with.

There being time to spare before dinner, a party proceeded, under the guidance of Mr Lucy, to inspect the cutting at Over, on the new line of rail from Gloucester to Ledbury. This section shows at the base a band of stone one foot thick, much jointed, in which are found *Ammonites stellaris*, with *Lima gigantea*, and *Gryphœa arcuata*; then follows a bed of clay, eight inches, upon which rests one foot six inches of clay with peat, which is succeeded by ten feet of "Boulder Clay," formed out of the Lias, in which are numerous pockets of Quartzose Sand, and on the top is four feet of "Till," with "Northern Drift" pebbles in great abundance. Mr Lucy called attention to a drift about ten yards in width, which crossed the cutting in the ten feet bed of "Boulder Clay" at a very acute angle, and was composed of "Northern Drift," with much Quartzose Sand, and he pointed out that it came in a direct line from Sandhurst, which is capped by the same drift, which extends to Hempstead, where it is again met with. Mr Lucy expressed his belief that this quaternary deposit took place at the three localities at the same time, and showed, by its relation to the present low-lying meadows, how great and extensive must have been the denudation which has since taken place. Mr Lucy showed by a section at Lassington, at a distance of a mile and three quarters from Over, that the *Ammonites planorbis*, rare in this district, occurs, and that the "Rhætic" beds are there represented by a thin band of stone six inches thick, which contains *Monotis decussata*, and about three feet of "Tea-green Marls," the "bone bed" and "paper shales" of Westbury being absent.

The members dined together at the Bell Hotel.

THE FIRST FIELD MEETING

of the season was held on Tuesday, 27th May, at

CHIPPING NORTON.

This locality is somewhat outside the boundary of the county, but it offered special attraction to the Geologists of

the party, inasmuch as it afforded them an opportunity of comparing the Inferior Oolite on the north side of the Great Oolite plateau with those more familiar beds of the Cotteswolds to the south of the same region.

The party assembled at the White Hart, Chipping Norton, where carriages were in waiting. Their attention was first directed to the cutting on the Cheltenham and Banbury Railway at Hook Norton. Here they were joined by Mr E. A. Walford, the author of a paper in the *Quarterly Journal of the Geological Society* on "The Relation of the so-called Northampton Sand" of north Oxon to the "Clypeus-grit." Some opposition was manifested by the contractor to the inspection of the cutting, but on the President and Vice-President giving their names, the party was permitted to proceed without further molestation. Those who would master the details of these remarkable sandy beds, so different from any of the Cotteswold type, should study the paper by Mr Walford in the number for May, 1883, of the *Quarterly Journal*. At the point examined the cutting presented a section of about thirty-six feet of Inferior Oolite, resting upon Upper Lias Shales. Of these Oolites the lower six feet consist of rock, in which has been found *Rhynchonella cynocephala*, which in the Cotteswold characterises the lowest bed of the series. The upper sandy beds have yielded *Ammonites Parkinsoni*, which is characteristic of the upper beds of the Inferior Oolite. It would thus seem that the middle series is absent, and that only the highest and lowest beds are represented in the section. These arenaceous beds are so entirely dissimilar to any in the Cotteswolds that it is evident that totally different conditions prevailed in the relations of land and water at the period of their respective deposition.

The party having despatched a very welcome luncheon, gipsy fashion, under a sheltering hedge, proceeded to the Church at Hook Norton, which has been much altered at various periods. Besides the remains of Norman work it contains a remarkable round font, on which are figures of Adam and Eve and other rude sculptures.

The carriages now took the direction of the Rollright Stones, stopping by the way to examine Rollright Church, in which the most noteworthy object is the richly decorated tympanum and arch of the western doorway, of late Norman work. Presently the Rollright Stones came in view. These are treated by all writers on British antiquities, and various are the opinions of Antiquaries as to their object and origin. FERGUSON, in his "Rude Stone Monuments," and CAMDEN regard them as memorials of battle, and of post-Roman date, while others conceive them to have been temples of the Druids in times long before the invasion of Cæsar. The latter is mere guess-work, but FERGUSON adduces proofs and illustrations of his theory, which will go far to satisfy enquirers. It is a 100-foot circle, having, as is usual, one stone in the circuit taller than the rest. This stone has certainly been partially dressed on the surface. Northwards is a detached monolith, called the "King-Stone," and at the distance of a quarter of a mile in a different direction is a dolmen, the cap-stone of which has fallen. These go by the name of the "Five Knights." A view of the circle, taken from the representation in PLOT'S "Oxfordshire," will be found in PHILLIPS'S "Geology of the Thames Valley."

The horses' heads were now turned in the direction of Chipping-Norton, halting by the way at Langdon Bridge, over the railway, where a somewhat doubtful section presented itself for elucidation. The base showed a thickness of white Oolitic Limestone, wholly unfossiliferous, the position of which is above the "Clypeus-grit," and below the Great Oolite. On this rests a band of blue clay, overlaid by sandy beds and a layer of small oysters. It was determined that the Oolite rock constitutes the upper member of the Inferior Oolite, and that the blue clay band represents the "Fuller's Earth" at the base of the Great Oolite.

Haste was now made for Chipping Norton, where some of the party had to catch an earlier train than the rest. The remainder stayed to dine at the White Hart, and had leisure before dinner to examine the quarry, which has yielded the bones of the *Ceteosaurus*, whose story occupies many pages of PHILLIPS'S

"Geology of the Thames Valley." It was an enormous reptile, dragging upon the earth a length of between sixty and seventy feet, and of proportionate bulk. The quarry was found to exhibit a section identical with that at Langdon Bridge, namely, Oolitic rock, overlaid by a band of blue clay, and a bed of small oysters. The Saurian remains come out of the blue band, which, with the sandy beds above, may represent estuarine conditions very favorable to a reptile of such magnitude.

THE SECOND FIELD MEETING

for the season took place on Tuesday, 24th of June, at

DURSLEY.

The members assembled at Dursley Railway Station, on the arrival of the 10.55 train, and drove to Cam Longdown, up which hill they climbed, and Mr Witchell described the features of the surrounding district. They were, he said, standing on strata which marked the commencement of the Oolitic period, and on the dividing line between the Oolitic and the Liassic series. Below them the sand was some 200 feet thick, and overlaying the sand were the "Cephalopoda" beds, so-called on account of the number of "Cephalopoda" which characterised them. Above these beds succeeded the basement beds of the Inferior Oolite, the lowest of which consisted of sandy Limestone, very hard and compact, and to this bed was due the preservation of the ridge on which they were standing. The same bed extended through the Cotteswolds, and was found at Leckhampton hill. In the section of the quarry at the south end of the Down they would be able to trace the bed from the base upwards, showing the gradual development of the Oolitic structure. The absence of the remarkable bed known as the "Pea Grit," which at Leckhampton presents so striking a feature, was specially remarked upon. Mr Witchell then called attention to the grand example of denudation which the country around exhibited. The whole of the Dursley valley has been excavated by denuding influences. Some Geologists attributed the denudation to glacial action, but the glaciers, if

they existed, have left no trace behind them. Other Geologists attributed it to marine action, but the sea had left no trace, and in the combes and hollows of the hills no trace of a marine beach could be found. In the beds of gravel the shells found belong to land and fresh water species; so that there only remain sub-aërial agencies to account for the changes which have taken place.

The party then visited the various sections on the hill, making a prolonged stay at the "Cephalopoda" bed, which had been purposely quarried to enable members to obtain characteristic fossils.

On leaving Cam Down the Club partook of luncheon at the Bell Inn, Dursley, after which the carriages conveyed the party by way of Stinchcombe and Nibley to near Westridge Wood, to enable the members to see a British Camp on the summit of the hill. The Camp occupies an area of about four acres, enclosed by two ramparts. Surrounding it are numerous remains of pit dwellings, which have been brought to view by the clearance of the woods. At one spot there is a group of four large pits, nearly circular in form, having a diameter of 100 feet. They appear to have been from seven to ten feet deep, but are now filled with stones and stumps of trees. Mr Witts remarked that previous to the examination of this Camp he had entertained some doubts as to the genuineness of these pit dwellings, but that now his doubts were entirely removed. Some tracings from the map of the Geological Survey, sent by Mr J. H. Cooke, proved very useful as a guide to the Camp, the paths to which were very accurately shown.

The party having re-entered their conveyances, drove to Tait's Hill quarry, near Dursley. This quarry is placed in the zone of the "Middle Lias," which is divided by Geologists into five sub-zones, each distinguished by an Ammonite, which is regarded as characteristic of the zone in which it is found. The quarry has been regarded as belonging to the second or zone of *Ammonites margaritatus*, the upper or zone of *A. spinatus* being thought to be wanting. Mr Witchell and others were however of a different opinion, and it was not long before

doubts were set at rest by the finding of the fossil *in situ*. The question was thus determined, and it is now certain that the top beds in the quarry are those of *Ammonites spinatus*, while the beds at the base are those of *A. margaritatus*. Some other good fossils were obtained, including *Belemnites paxillosus*, *Pecten æquivalvis*, *Rhynchonella tetrahedra*, *Terebratula punctata*, &c.

The party dined together at the Prince of Wales Inn, near the Berkeley Road Station.

The Club held their

THIRD FIELD MEETING

for the season on Monday, 21st July, at

LEDBURY,

with the view of visiting the "Passage Beds" between the "Old Red" and the "Silurians," and of inspecting the beautiful and interesting parish Church. The party travelled by train to Ledbury, where they were met by Mr George Piper, a local Geologist, who has during many years made a continuous study of the rocks in question. The section which has been laid open by the railway presents the finest, perhaps the only complete display of these beds known to Geologists, and as such is deserving of the most careful study. Ascending a hill on which a rail is laid for the transport of stone, the entire succession of beds, here nearly vertical, with a slight dip to the west, is displayed to view. To the westward the "Old Red" stretches in unbroken continuity as far as Milford Haven. At Ledbury it is met conformably by the Silurian beds, which are connected with the "Old Red" by the so-called "Passage-Beds," which are here displayed in their entire extent. The recent cutting at the eastern end of the great excavation near the railway station, has laid bare the lowest of the "Passage Beds," and has exposed to view all the upper Silurian strata down to the "Lower Ludlow" beds, which here attain a thickness of many hundred feet, and rest immediately on the solid beds of the "Wenlock Limestone." To describe the "Passage

Beds" in detail would require more space than is here admissible, but they have all been carefully measured and described by Mr Piper, in a paper read by him to the Cotteswold Club. They consist of a series of red and white bands, forming a very extensive succession of beds, some of which are wholly unfossiliferous, while others contain fish of "Cephalaspidean" type, known as *Auchenaspis Egertoni* and *A. Salteri*. These, owing to the gritty nature of the rock in which they are found, are more or less obscure, though numerous, and consist almost invariably of the head and neck plates, but Mr Piper has had the good fortune to obtain two bodies, the only examples as yet discovered. These fossils were first discovered by a cobbler at Ledbury, since dead, of the name of Brookes, an enthusiastic and successful worker in these beds. Besides these organisms these beds have also yielded rims of Cephalaspidean head-shields, and examples of *Cephalaspis Lightbodii*, *Pterygotus*, a large *Lingula*, and *Onchus*. Other beds contain *Cephalaspis* and *Lingula*, which latter seems to run through them all. Twenty-four beds of Sandstone, Shale and Marl are enumerated by Mr Piper as forming the true "Passage Beds." To these succeed the Downton Sandstone, fifty-eight feet in thickness, then the Upper Ludlow Shales, Aymestry Limestone, and Lower Ludlow, which terminates the section.

After luncheon, at The Feathers, the party proceeded to visit the Church, under the guidance of the Rector, the Rev. J. Jackson, who told the story of the modifications it has undergone with a mastery of detail which a long and loving study could alone have enabled him to do. In the first place there was a Norman Church of the same length as the present one, as is shown by the remains of architecture of that period at both ends. The old Norman Church had low and narrow aisles. The choir shows Norman windows below, and circular ones of the same period above, surmounted externally by the original corbel-table, once without the Church, and now within it. The north aisle was removed and widened, and the beautiful lancet window introduced at the east end. The Norman piers and arches of the nave were next altered to their present

form. The chapels were thrown out, that of St. Ann on the south, and of St. Catherine on the north, the latter a perfect gem of Decorated architecture, encrusted all over with the "ball flower." The Norman south aisle was removed, widened to the extent of St. Ann's chapel, and continued to the west end at two intervals, the last south-west window having been evidently the last inserted. There are many other curious details—as those of the angular hood-moulds over the doorways, and the lychnoscope, which may possibly belong, as suggested by Mr Jackson, to an earlier Church, but this is doubtful. In St. Catherine's chapel is a figure of a lady in the dress of the early part of the 14th century; she reposes on an altar-tomb, over the edge of which her drapery falls in graceful folds. The tomb is of a date altogether later than the figure, and on closer examination it is seen that the figure and the slab on which it rests have been moved from somewhere else to their present resting-place, with which they have no connection. On the monument are carved armorial escutcheons, but to whom either the figure or the tomb were erected there is neither evidence nor tradition to show.

The party dined at The Feathers, after a day of unusual interest and instruction.

THE FOURTH FIELD MEETING

of the Club for the season was held, by the kind invitation of Handel Cossham, Esq., on Tuesday, the 12th of August, at

KINGSWOOD,

Carriages were in waiting for the party on the arrival of the train at Fishponds Station, where Mr Handel Cossham met them, in company with their old and valued colleague, R. Etheridge, F.R.S.

The route lay through Frome valley and Stapleton to Stoke House, a dower-house, belonging to the Duke of Beaufort, now leased to Admiral Close, a son of the late Dean of Carlisle. The house occupies an imposing position on a lofty knoll,

overlooking the country around Bristol to the far-away Mendips, in the blue distance. On arrival they were met by Admiral Close, who led them through the lower rooms of the house and along the noble stone terrace, from whence an extensive panorama over the surrounding country lay spread before them. From this commanding elevation the party was addressed by Mr Cossham and Mr Etheridge on the geological features of the district. They were told that they were looking on the "New Red Sandstone," which lay under the grassy slopes of the park at their feet, to which succeeded the Pennant Sandstone of great thickness, overlying the coal-field of Kingswood and the Bristol basin. Beyond Bristol the eye rested on a bold ridge of Carboniferous Limestone, which runs out into the Bristol Channel at Portishead, and forms a portion of the great ring of that formation, which, passing by way of Wickwar, Wick Rocks, &c., forms a boundary to the Bristol coal-field. The party rested here for some time, enjoying the beautiful prospect, and the courteous attentions of Admiral and Mrs Close, until it was time to move to Kingswood, where, under a tent near Holly Lodge, the residence of Mr Cossham, they found an ample and most attractive repast set out for their refreshment.

The good things being duly enjoyed and grace said, Mr Cossham proposed "The Queen," after which he proceeded to read a paper which he had prepared on "A late discovery in the Kingswood coal-field." He alluded first to the very complicated structure of the Bristol coal-field, and to the difficult problem that it presents for solution. Some twenty years ago Mr Cossham challenged the accuracy of the geological maps of the district, which up to that time had shown a large development of "Millstone Grit," (the Farewell Rock of the miners) that was supposed to have been protruded across the coal-field between Bristol and Wick; and by proving that this supposed "Millstone Grit" was in reality only one of the siliceous Sandstones of the coal-measures, made room for the suggestion, which has since proved to be correct, that the coal-bearing strata extended south of Kingswood and St. George, under the

river Avon, and probably on continuously to the Mendip hills. "But to-day," said the speaker, "it is my good fortune to be able to tell you of a discovery I have lately made that will, I think, have a much more important bearing on the future of mining industry in this district than the one I have already referred to."

After describing the early shallow workings, Mr Cossham stated that it was only fifty years ago that the "Great Vein" series was discovered, which has since been largely worked on a south dip, and over a considerable area. With a view to exposing the whole of the area (about 2000 acres) the mineral freehold of which Mr Cossham purchased some years ago, an exploring drift was driven to the south at a depth of 68 fathoms, to cut the upper section of seams that lie over the ordinary Kingswood series; and at the same time another drift was started to the north, at a depth of 500 yards from the bottom of the Speedwell Pit, and it was the discovery made by the latter which formed the subject of the present notice.

For some 200 yards the drift was driven through strata nearly upright, and showing proofs of enormous disturbance and displacement. The object in driving this deep tunnel was to strike the lower or Ashton series of veins. About 250 yards north of the Speedwell Pit a seam of coal was cut about two feet four inches thick, lying in an upright position. As the drift was extended northwards the strata became horizontal. Other veins of coal were met with, still supposed to be in the lower series, but further experience showed them to belong to the "Great Vein" group which had been worked 300 to 350 yards overhead, up to the outcrop of the vein near the surface. Hesitating to accept the conclusions to which this led, Mr Cossham caused drifts to be driven above and below, and on the 21st of the previous February discovered the Kingswood "Great Vein" lying *in situ* of an average thickness of five feet. Since then these veins have been worked north, south, east and west, and are found to constitute the original floor of the coal-field, with a gentle dip of three inches in the yard to the west. Not the least interesting feature of this discovery

to the proprietor lies in the fact that it has revealed the existence of from six to eight millions of tons of coal in his mineral estate which he had no expectation of having.

The explanation of these facts is this—that there has been in the past history of this district a time when the whole of the Palæozoic strata, including the coal-measures, have been pushed by a force, exerted on the south, bodily over the top of the coal-field of the district. Mr Handel Cossham believed that the centre or focus of the force which has thus thrust a portion of the coal-field over itself is to be sought in the up-thrust of the Mendips after the deposition of the coal-measures, and prior to the deposition of the secondary rocks, by which the whole country to the north, and possibly to the south, was thrust forward. Mr Cossham concluded his very interesting paper, illustrated by maps and sections, by a reference to the important bearing which this discovery has upon the mining industry of the district, an industry which is so intimately associated with the future of our country.

Mr R. Etheridge, F.R.S., in reply to the toast of his health, which was very cordially received, made some remarks upon the more salient points of Mr Cossham's paper, in the importance of which and of Mr Cossham's splendid discovery, he entirely concurred.

The health was likewise drunk, and very warmly received, of the President, of their munificent entertainer, Mr Cossham, and of Admiral Close, after which the party separated and dispersed to their different destinations.

THE FIRST WINTER MEETING

of the Club for the season was held at the Lecture Theatre of the

SCIENCE SCHOOL IN GLOUCESTER,

on Tuesday, 16th December, when papers were read by Mr W. C. Lucy, F.G.S., on "The Sutton Southerndown and Dunraven Beds, in Glamorganshire," and by Mr E. Witchell, F.G.S., on "The Forest Marble and Great Oolite between Nailsworth and Wotton-under-Edge."

The President opened the meeting by addressing a few words to those present on the great loss just sustained by the Society in the death of their old friend and Vice-President, Dr Wright, a loss which he described as irreparable.

The paper by Mr Lucy on "The Sutton and Southerndown Beds," was the result of a week's study of the ground, in company with Mr Tomes. These beds have formed a *erux* for Geologists, and have been treated by Messrs Tawney, Etheridge, Moore, Bristow and others, and it would seem that the last word has not yet been said upon them. The main object of Mr Lucy's paper was to show that the beds at Sutton belong to the "White Lias," and that some conglomeratic beds which occur east of "the caves," and belonging to the Lias, had been mistaken for the "Sutton Stone," to which the beds in question bear a great resemblance; and Mr Lucy is of opinion that many of the supposed "Sutton-Stone" fossils have been derived from these liassic beds. An extract was given from a recent paper by Mr Tomes, in the *Quarterly Journal of the Geological Society*, which shows that the corals collected at Sutton are of St. Cassian species, none of which occur at Brocastle.

This paper was illustrated by several inland and coast sections.

Mr Lucy exhibited a well preserved tooth of Mammoth *(Elephas primigenius)* from the gravels of Cainscross, near Stroud.

Mr Witchell then read his paper on the "Forest Marble and Great Oolite between Nailsworth and Wotton-under-Edge." The paper was the result of work done in the previous month of October, when the author went over the ground, in company with Mr C. Playne and Mr Alfred Smith. He found the Geology exceptionally interesting, inasmuch as it enabled him to trace the thinning out of the beds of white limestone, (Great Oolite) and of the shelly beds of Minchinhampton, belonging to the same formation. The limestone ceases near Kingscote, and in the same locality the shelly beds lose their shelly character, and become weatherstone beds, formed of shelly detritus ground down into fine particles of

sand and oolitic granules. The junction between the White Limestone and the "Forest Marble" was well shown in the quarries at Tiltup End, and the upper bed of White Limestone, and a thin band in one of the quarries lying upon the Limestone, contained a large assemblage of fossils, chiefly of the genus *Nerinæa*. The shells, specimens of which were exhibited, were exceptionally large. Corals were also found in the bed, and small round concretionary lumps covered with *Bryozoa*. From the discovery of this assemblage of fossils, and a similar one recorded by Dr Lycett on the same horizon, but on the east side of Minchinhampton, Mr Witchell thought there was evidence of a pause in the Oolitic deposits, and a change of level and of marine conditions between the Limestone period and that of the overlying "Forest Marble."

THE SECOND WINTER MEETING

of the Club for the season was held in the Lecture Theatre of the

SCIENCE SCHOOL IN GLOUCESTER,

on Tuesday, the 3rd of February, 1885, when a paper was read by Edward Wethered, F.G.S., on the "Structure of Carboniferous and Cretaceous Coal." Much has been written on the subject of the structure of coal since De Luc, in the year 1793—5, first contended that it was the product of vegetation which grew on the spots where the seams now rest. An important addition to our knowledge of the question was made by Sir William Logan, in 1841, who pointed out that under every seam of coal there was a stratum of clay, known as the "under clay," in which a fossil vegetable, *Stigmaria ficoides*, was always to be found, and subsequent discovery proving it to be the root of Lepidendroid plants generally, led up to the idea that coal was formed mainly from the submergence of forests of *Lepidodendra*. In the year 1870 Professor Huxley modified this view by attributing the formation to accumulations of spores of that class of vegetation, the wood forming the mineral charcoal. Among those who advocated the submerged forest theory were

Sir William Dawson and Mr Carruthers. In the discussion of a paper read by Mr Wethered before the Geological Society last year, Mr Carruthers said: "Seams of coal are the remains of forests that grew upon swampy ground, and were subsequently covered by clay." Sir William Dawson, in his "Acadian Geology," says: "The plants which have contributed the vegetable matter of coal are principally *Sigillariæ*, with *Cordaites* Ferns and Calamites. With these however are intermingled remains of most of the other plants of the period, contributing in an inferior degree to the accumulation of the mass." Without in any way wishing to undervalue the great work done by these eminent men, it is necessary to understand how they came to their conclusions; bearing in mind that in a previous paper read to the Club mention was made of the connection of *Cordaites* with coal.

Sir William Dawson's method of examining the mineral was to submit pieces containing the tissue of a single plant to the action of boiling nitric acid, the residue being washed and submitted to microscopic examination. Mr Carruthers obtained his information from certain mud-balls in the British Museum, said to have been derived from seams of coal in which Mr Carruthers finds the remains of carboniferous forest growth. Mr Wethered objects to both of these processes as giving unreliable results as to the nature of coal in general, and appeals to the evidence of recent bogs to show how future coal-deposits are accumulating at the present day. In a recent peat-bog, the vegetation which constitutes the mass of the bog is formed by the peat-mossess (*Sphægnaceæ*). Growing on the top, however, are Conifers and other trees. Such a bog being submerged, would pass from peat to lignite, and thence to coal; such coal would contain the trunks of trees; but were it thence to be concluded that the coal owed its origin to the trees, a very erroneous idea would be formed. Mr Wethered objected to Sir William Dawson's method of selecting a portion as representative of the mass, and likewise to the treatment in boiling nitric acid, which must ensure loss and destruction of substance and structure.

Seams of coal are spoken of as if they consist of a solid and uninterrupted mass of mineral, and this is often true in cases of thin seams; but for the most part seams are found to be made up of more than one layer, separated by earthy partings; from which it is clear that in the case of thick seams there is a break or breaks in the accumulation of the mass. Next, as to microscopic structure. If we examine a piece of coal we find it to be built up of layers, which may be divided into bright and dull layers. In the latter, as a rule, the spores of plants are met with; some indeed may be said to be made up of them. In the bright layers, and in bright coals generally, these bodies are less numerous, and wood tissue becomes more abundant.

Of the spores themselves there are two kinds, macrospores and microspores. Assuming that they belong to plants allied to the *Lycopodiaceæ*, it is clear that they cannot belong to the *Lycopodieæ*, as the latter have *but one kind of spore.* The *Selaginelleæ* is the only other family of the *Lycopodiaceæ* which are terrestrial plants. They have macrospores and microspores, and are considered by Mr Carruthers to be represented in carboniferous times by *Triplosporites* (Brown), but it is a question yet to be decided whether the coal plants were allied to that genus. There is another class of plants belonging to the *Lycopodiaceæ;* these are the *Isöeteæ* which are of aquatic growth, and they have macrospores and microspores, which are very similar in appearance to those detected in coal.

Coming to the cretaceous coal, the specimens of which were collected by the lecturer from a cretaceous coal or lignite, which extends under a portion of the third Prairie Steppe of the north-west of Canada. It is difficult on inspection to believe that one is not looking at carboniferous coal; there are the bright and dull layers well defined, which at once suggests a like mode of deposition. The bright layers show, on microscopical examination, the same structureless material as detected in the bright layers of the carboniferous coal; but in addition there is evident a large accumulation of minute discs, measuring about 1-1000th of an inch in diameter, the nature of which is not yet determined, but possibly they may be spores of

plants. In the dull layers, wood tissue is met with, but the specimens are too much decomposed to admit of drawing any conclusion from them. The cretaceous coals are, however a confirmation of what has been before stated in respect of the carboniferous coals, namely, that they have been accumulated in much the same way as the lignites and peat bogs of more recent times, further modified by time and pressure.

Professor HARKER had examined the slides prepared by Mr WETHERED, and was of opinion that the spores are more nearly allied to those of the *Isöeteæ* than to those of the other families of Lycopods.

The paper was illustrated by a fine series of diagrams, while three or four microscopes on the table enabled the members to verify the forms, of which the diagrams presented enlarged representations.

THE THIRD WINTER MEETING

of the Club for the season was held in

GLOUCESTER

on Wednesday, March 11th, in the present year, when a paper was read by Professor HARKER on "The Habits of some Annelids found in Gloucestershire."

This paper arose out of certain queries addressed to the lecturer in the spring of last year by the President of the Club, whose attention had been called to the subject by a lady who had collected a quantity of these obscure forms of animal life from an adjoining pond. This animal, the *tubifex rivulorum*, is of common occurrence in the mud of ponds and streams; it is of a red colour, from one inch to an inch-and-a-half in length. Where it is prevalent it colours the mud red, but so sensitive is it that the stamping of a foot in the neighbourhood will cause the whole colony to disappear, in which action it withdraws to such a depth and with such rapidity that it is not easy to

obtain specimens for examination. Professor HARKER finds two species inhabiting the mud, one selecting decayed vegetation, and another very active and handsome, dwelling in the colonies of *Spirogyra* and *Vaucheria* in canals and lakes. He described at some length the anatomy of the species. He then described his experiments and observations made on the worms when kept in tanks in the laboratory of the College at Cirencester. The result of his experiments led him to conclude that the *Tubifex rivulorum* does not make tubes of any kind, though all writers on the subject, notably DONNET, LAMARCK, and D'UDEKEM have described it as a tube maker. He explained in detail his reasons for arriving at this conclusion. The life-history of these small annelids is, owing to their habits, a matter of some difficulty; indeed, the investigations can hardly be carried on by continuous observations under natural conditions. Professor HARKER stated that he had caused some tanks to be fitted up, with a view to carry on such observations, and he hoped to have some further remarks to communicate to the Club on a subsequent occasion.

Mr WITCHELL exhibited a nodule from the Inferior Oolite of the neighbourhood of Stroud, which, on being fractured, revealed the ink-bog of a *Sepia*.

THE FOURTH WINTER MEETING

of the Club for the season was held on Tuesday, March 31st, in

GLOUCESTER,

when a paper was read by Mr FRANCIS DAY, F.L.S., entitled, "Notes on the Breeding of the Salmonidæ." Mr DAY observed that although he had been favoured with permission to visit regularly the experiments in fish culture now being conducted at Howietoun, N.B., he had arrived at the conclusion that he might, with very simple apparatus, carry out additional experiments of his own at Cheltenham. The object of his experiments was to ascertain—(1.) Can Salmon spawn in the sea? (2.) Are the eggs of fishes of the same species identical in size, no matter the age and weight of the parent, and if they differ,

on what does such difference depend? (3.) Are all the eggs in any one fish of the same size? and (4.) What is a Par? The apparatus employed consisted of a paraffin cask having a tap near its lower end, a supply tank made of deal, and two hatching-trays, all the foregoing being charred inside and painted externally with Brunswick Black; these, with an extra tub to contain a further supply of water, a bucket and a leech-glass as an egg-picker, constituted the whole of the articles used, which were raised to their proper positions on old empty boxes in an unused coach-house. On November 28th he received from Howietoun 500 eggs of the Loch Leven trout, which had been spawned on the previous day; these were sent by rail, and, on arrival, the end of the cigar-box in which they were contained was found to have been broken in, and a portion of the cover cracked, owing to the rough usage which it had met with in transit. The eggs were in layers on muslin, packed in damp moss; and as it has been asserted that injury to the eggs during the first few days after they have been taken, is likely to cause malformation or monstrosities in the young, it is worthy of remark that in only one instance was such effect perceived, and in that one the young fish had two heads, but still lives. On February 17th, being the 82nd day, eleven hatched in the trays, and one on the 20th, while on visiting the trays upon the following morning the young were all found dead and the waters smelt strongly of paraffin; so all was at once thrown out, and fresh used; the cask which was suspected of being the cause, was rejected. On the 22nd some hundreds of young fish presented themselves, and they continued hatching until the 29th. As so many have described the appearance of the young fish when just hatched, a detailed account was not gone into, but a coloured diagram was exhibited, giving in a highly magnified form the appearance of the salmon on the day of hatching. The young fish mostly come into the world head first, the egg splitting down the back, but in one instance the young was choked before it could make its exit. Another young fish emerging tail first, had its head caught in the shell, and there for five days was held a prisoner,

like a cat with its head in a stocking, but was relieved by a sharp pair of scissors. In order to ascertain whether light exercised any deleterious effect upon eggs, several were placed upon a white earthenware palette in a hatching-tray, the cover of which was removed, but in due time all of them hatched. It has been from time to time promulgated that Salmon can spawn in the sea; in fact, one of the luminaries of the Scottish bar, distinguished for his grave eloquence, declared that were all the rivers in the kingdom blocked up, they could then be *forced* to spawn in the sea. Here, then, was a question that seemed worthy of investigation, so having, through the kindness of a friend, obtained salt water from Weston-super-Mare, it was employed for this purpose, dilution being effected by means of pump water. On January 9th, 1885, two eggs of Loch Leven trout were placed in a pint tumbler of sea water, having a specific gravity of 1,019 degrees; there were 2½ inches of water above the eggs, while the tumbler was placed in a hatching-trough, through which water was kept flowing, but not sufficiently deep to reach more than two-thirds of the distance up the outside of the glass; this water was changed daily. They were dead in 48 hours. This experiment was repeated on the 21st, but they succumbed in about 4½ days. On January 23rd two more Loch Leven trout eggs were similarly placed in saline water standing at 1,012 degrees; they lingered on but never hatched. January 24th two more eggs were placed in a tumbler of brackish water diluted to 1,008 degrees, and treated as the preceding ones; on the 28th one hatched, and on March 1st the other, but scarcely in a normal manner. First the yolk-sac appeared, and, when the little one emerged, it was found to have dropsy, and lived only a few days. As dropsy of the sac is a disease due to want of vitality, and as this was the only fish so affected, it is reasonable to conclude that the residence of the egg in brackish water had proved detrimental to the vigour of the offspring. To make sure that the plan adopted had not been injurious, two Loch Leven Trout-eggs were placed in a tumbler of fresh water, and hatched in due course. Salmon eggs having likewise been received from Howietoun, showed results very similar to those

from trout. On January 18th three Salmon-eggs were placed in tumblers of salt water at 1,021 degrees; all were dead in three days. On the 22nd this was repeated, but none survived the third day. On the 19th three were placed in salt water at 1,012 degrees, and died in three days and two hours. On the 28th this was repeated, but the eggs were dead at the end of the fourth day. On the same day two more eggs were placed in brackish water at 1,007 degrees, but they died in four days. This was repeated on February 1st, and on the 9th one hatched and the other was alive. On the 18th and 21st two eggs were placed in tumblers of fresh water, and hatched out in due course. In the report of the Commission on the Salmon Fisheries in 1824, we find witnesses asserting, as did Mr Steavenson, that "there cannot be a doubt that Salmon spawn in the sea;" but Mr Hogarth tried the experiment in 1824, and found that such treatment was fatal to them. Sir John Matheson, in 1861-62, again tried the experiment, but it failed; and Dr John Davy, employing a solution of common salt at 1,007 degrees, found some alive on the fourth day. Brown dropped some eggs into sea water, and they at once turned white and died; and Sinclair's endeavours met with no better success. Respecting the size of the eggs of these fishes, we find that in 1767 Harmer wrote in the transactions of the Royal Society a paper on the "Fecundity of Fishes," remarking that the size of the eggs is nearly the same in great and small fishes of the same species at the same time of the year; others have asserted that the size of those of each species is unvarying. Professor Malmgren, in 1862, ventured to assert that the salmon in the Scandinavian lakes were a land-locked race, the relicts of some which in a former condition of the country had been able to migrate into the glacial ocean; and among other things, that they were smaller in size, and gave eggs which were less than those normally seen in the salmon. A celebrated museum ichthyologist snubbed the unfortunate professor in a way it is not worth while to repeat, while the poor man was probably in the right. Then M. Blanchard, in 1866, tells us that the eggs of the grilse are smaller than those of the salmon. Livingston-Stone states that brook trout on

limestone formation, which means a diminished food supply, give eggs much smaller than those of more highly-favoured localities, while it has been conclusively proved at Howietoun that their size increases with the age of the parent, so long as their fertility is unchecked; while in every fish about five per cent. of the eggs are below the average size; also that the thickness of the shell (*zona radiata*) of the egg increases with the increased age of the mother. It has been proved at Howietoun that larger eggs give quicker-growing offspring; consequently, those who wish to obtain the finest forms should obtain them from where care and attention are paid to the segregation of the parents. At Howietoun the old trout give eggs the same size as do the grilse.

The last subject entered upon was, "What is a Par?" This is a question on which learned divines, lawyers, doctors, naturalists, magistrates, and poachers, have all differed, and which difference has caused the arousal of a vast amount of ill blood, and all because no one would take the trouble to hatch out a few salmon eggs, and trace the various phases through which the fish passes. It was not until Mr Shaw did this that science became satisfied, but even then some individuals, instead of being convinced, merely became enraged. The whole history of the controversy was traced from the time of Gesner until the present, and how it was treated in works of Natural History and even in law books. Also how at Howietoun, in 1880, eggs of salmon were obtained and hatched in the establishment, and in 1884 eggs and milt were taken from fish so reared, which *had never gone to the sea*, and now over 2,500 young fish have emerged from those eggs. Mr Day also exhibited under the microscope scales of the par, smolt or grilse, and of the salmon, showing that the scale of the par is not so broad as are those of its older relatives. He also showed the micropyle of the eggs of the salmon and trout, the first having depressions around the orifice, but not so the trout in any of its varieties.

This terminates the records of our proceedings during the past season, which, I venture to say, compares favourably with its predecessors, and manifests no falling off in the energy and activity of the Cotteswold Club.

Paper on the late Discovery in the Kingswood Coal-field. Read by HANDEL COSSHAM *before the Cotteswold Naturalists' Field Club, August 12th, 1884.*

The Bristol Coal-field, and especially the northern portions of that field, is a very complicated piece of Geology—very difficult to read accurately—and has had repeatedly to be re-written, in order to conform it with ascertained facts, and make it consistent with new discoveries. My business relations have brought me into close, and constant, contact with the Geological problems of this portion of the county; and I confess that the endeavours to unravel the Geological intricacies of the country lying between Bristol on the south, and Wickwar on the north, has been, to me, not only a source of profit, but an ever growing subject of interest and delight.

It has been my singular good fortune to make one or two discoveries that have considerably extended the boundaries of the Coal-field, and of laic under tribute large quantities of valuable mineral, where such deposits were not supposed to exist.

I claim no particular credit for this; it has been the result of the fortunate, and favorable, position in which I have been placed for making observations, and conducting under-ground investigations.

Some twenty years ago I challenged the accuracy of the Geological Maps of this district, which up to that time showed a large development of Millstone Grit (or Farewell Rock) that was supposed to have been protruded across the Coal-field between Bristol and Wick, and by proving that this supposed Millstone Grit was only one of the Silicious Sand Stones of the Coal Measures lying between, and dipping conformably with, certain well known beds of Coal that lie below the Pennant

rock, made room for the supposition which has since proved to be correct, namely, that the Coal-bearing strata extended south of Kingswood and St. George, under the river Avon, and on (so far as I know) continuously to the Mendip Hills. That discovery has had an important bearing on the mining industry of this district, and will help, in the future, to unlock the mineral resources of the neighbouring county of Somerset south of the Avon.

But to-day it is my good fortune to be able to tell you of a discovery I have lately made that will, I think, have a much more important bearing on the future mining industry of this district than the one I have already referred to.

And first, let me trace the steps by which I have been able to make the discovery which I am about to explain; and to make it quite clear I must ask you to remember that the Kingswood section of the Bristol Coal-field contains the most ancient Coal workings not only of this county, but probably they are older than those of South Wales, Somerset, or Dean Forest. We have authentic records of Coal workings as far back as 1371, when EDWARD III issued a mandate to the Keepers of the Chase of Kingswood to allow EDWARD the son of HUGH BLUNT, Lord of the Manor of Bitton, to take, sell, and carry away wood, gorse, and SEA COAL found within the demesne, and by the second half of the 17th century I see by a map (that has passed to me as Lord of the Manor) that in the year 1672 there were no less than seventy small Coal pits at work in the Chase of Kingswood.

The workings down to the early part of this century were, of course, confined to shallow depths, chiefly drained by levels into the Avon or the Frome rivers, and were mainly confined to the upper section of the seams now working in the district.

About fifty years ago the Great Vein Series was discovered, and have been largely worked ever since on the south dip and over a considerable area.

Some time ago I resolved to explore the whole of the area (about 2500 acres,) the mineral freehold of which I purchased some years ago. To do this I commenced an exploring drift to

the south, at a depth of sixty-eight fathoms from my Belgium pit, to cut the upper section of seams that lie over the ordinary Kingswood series and between those and the Pennant rock; at the same time I started a drift to the north, at a depth of 500 yards from the bottom of Speedwell pit; and it is the discovery made by the latter, or north drift, from Speedwell, that I now venture to lay before you.

For some 200 yards this drift was driven in strata nearly upright, and exhibited traces of great disturbance and enormous lateral pressure, and in fact the whole of the Kingswood district has in past workings exhibited proofs of enormous disturbance and displacement, chiefly, as I some time ago explained in a paper which I published, having been produced by lateral pressure, and not by vertical movement.

I should explain that my object in driving this underground tunnel was to strike, as I expected, the lower or Ashton series of veins—in other words, the lowest section of seams in the Coal-field. With the assistance of a Section which two of the students of our Bristol Mining School have prepared, I shall be able to show you the steps by which I have reached the discovery we have lately made. Some 250 yards north of Speedwell pit we cut a seam of Coal about two feet four inches thick, in an upright position, and for a long time I supposed this to be the first of the lower, or Ashton, series of veins.

But extending the drift some 50 to 100 yards farther to the north we found the strata became horizontal, and we struck a *second* seam of Coal, in several separate beds, the thickest of which was about twenty inches thick. For some time I supposed *this* vein to be a second vein in the lower or Ashton series; but after following the vein for some 50 to 100 yards I found that it was one of our old Great Vein group that had been worked 300 to 350 yards overhead up to the outcrop of the vein, near the surface.

I hesitated for a long time to accept the conclusions to which this fact pointed, it was so difficult to explain or account for, that I resolved before coming to any decided conclusion

to drive cross measure drifts to the veins above and below, so as to prove the fact beyond doubt, before accepting it myself, or announcing it to others. I accordingly drove to the proper distance below this second vein, (known as the Giller's End Vein) and in the roof of which there is always found a particular, and remarkable bed of strata, known in the district as the "worm bed," and which we found in its proper position above this vein. I also knew that if I was correct in my opinion I should find at a distance of some thirty yards vertical above this vein the splendid seam, or bed of Coal, known as the Kingswood Great Vein (and which I have no doubt is the equivalent of the celebrated four feet Aberdare Steam Coal Vein.)

Accordingly I drove a drift across Measures, (as it is called) and on the 21st of last February discovered the vein known as the Kingswood Great Vein, lying in splendid *situ*, and an average of about five feet thick or from that to five feet six inches.

Since that time I have been driving on these veins north, east, south and west, and find that I am on the floor of the original Coal-field, with a gentle dip to the west and rise to the east of from three to six inches to the yard, and apparently extending to the north and east far beyond the bounds of my mineral estate. I do not want to trouble you with anything that is merely personal and commercial, but I am sure you will pardon me for saying that not the least interesting feature of this discovery to me is, that it has revealed the existence of from eight to ten million tons of magnificent Steam Coal in my mineral estate that I had no expectation of having, and that I can see clearly that for the next fifty to a hundred years at least the Collieries I work can go on landing a large quantity of splendid coal, at a cost that will enable those who work them to hold their ground against all competitors, come from where they may, and thus continue to develop one of the important industries of the district.

2nd. I now come to the more interesting and important enquiry as to how this Coal-field (and which I believe will prove to be the original floor of the district, though never seen or worked before this year) came to be found lying in the position I

have described. One thing you may take as proved beyond all controversy, namely, the seams of Coal we have found *are the same seams that have been worked*, under considerable difficulty, the last fifty years, arising from the dislocated and disturbed character of the district, and which have been worked for hundreds of yards to the north, over the head of the veins we have lately discovered.

That being the proved and ascertained fact, the aid of the Geologist, and Scientist, is required to account for and explain the phenomena before us; and I now venture to give you the best explanation I can, and ask your criticism and aid in trying to solve the problem with which we are confronted.

The only explanation that I can give is this,—

That there has been in the past history of this district a time when the whole of the Palæozoic strata, including the Coal Measures, have been pushed by some force exerted on the south bodily over the top of the Coal-field of the district; and, strange as it may sound, I believe it to be strictly true, that though this Kingswood Chase Coal-field has been worked more or less for some four or five centuries, the real Coal-field, or rather the original level of the Coal-field, has never been seen before the year 1884. It seems bold and almost rash for me to say this; but I am so satisfied that I am correct that if I were starting life again and had £100,000 to spare, I would willingly risk it on the correctness of this opinion. Fortunately, however, I have no need of expending any great amount of money to develop this new Coal-field, for, by singular good luck, my pits, machinery, and general arrangements, could not have been better placed for working this new field, if I had laid them out with that object, and with special regard to the state of things recently discovered.

If I am right in the opinion I have given, I must accept the responsibility of pointing out the probable centre and focus of the force that has thus pushed the Coal-field and all the intervening strata over the top of the real Coal-field; and I think I can spot the site of the force that has led to this remarkable Geological phenomenon.

The Mendip Hills, as you know, form the southern boundary of the Bristol Coal-field, but our distinguished President, Sir Wm. Guise, Mr Etheridge, and myself, were able two or three years ago, to gather proofs from the rocks of Carrington Park, near Bridgwater, that those rocks, which had previously been regarded as Devonian Limestone, were, after all, the Carboniferous Limestone, though in a highly crystalline condition, and very sparse of fossil remains. Being, however, genuine Mountain Limestone, they show almost certainly the existence of a Coal-field south of the Mendips.

My object in referring to this is to recall your attention to a fact that was proved by our friend Mr Etheridge and the late Mr Charles Moore, of Bath, beyond all question, namely, that the Mendips were lifted after the deposition of the Coal Measures, but prior to the deposition of the Secondary Rocks; and that when those Hills were thrust up by the volcanic force that in some portions has pushed the lava right through the Limestone and Old Red Sandstone, the whole country to the north, and possibly to the south as well, was thrust forward.

We know at Radstock, five miles north of the Mendips, this thrust has given Lady Waldegrave a double deposit of the Radstock or Upper Series of Veins. We must, however, I think look for the force that has thrust the Kingswood Coal-field over itself at a nearer point than the Mendip Hills; and I think if you will look at the enormous development of Carboniferous Limestone at Blackdown, Bourton, and in that district, we shall see the seat of the force that has caused this displacement.

It is singular and exceedingly interesting to note the effect of this thrust to which I am calling attention. If you will look at the map you will see that south of where we stand the river Avon has been pushed a mile to the north out of its natural course—by the same force (as I think) that has thrust the Coal-field over itself. And I happen to know that two or three miles below Bristol the level course of the seams of Coal, in the Coal-field, has been turned almost at right angles to its regular course by the same upheaval of Carboniferous Limestone and the displacement caused thereby; and the level course of the

workings on the south dip of the Coal-field at Kingswood, at a great depth, follows the remarkable bends in the river Avon to which I have called your attention; thus showing, as I think, pretty conclusively, that the force that has caused the one has produced the other; and I also know that the level course of the workings at the south liberty of the Ashton Colliery has been turned round by the same cause.

Allow me, Sir WILLIAM, in conclusion, to apologize for the imperfect way in which I have, I fear, explained this, to me, intensely interesting problem. It is one that will have a very important influence on the future of this district; and, as you well know, it is associated with an industry upon which the future of our country largely depends. Whenever England's mineral resources fail, her commercial supremacy must end, therefore every discovery that widens the area, and increases the extent, of our mineral resources should be regarded with interest.

The very pleasant visits to our district that you and the Cotteswold Naturalist Field Club have occasionally paid us have left on my mind such sunny memories that I felt that to-day you would allow me to place my first contribution relative to this recent discovery in our Coal-field at your service, with a hope that you may long continue the President of the Club, and that you may always be surrounded by the distinguished gentlemen you have round you to-day.

Southerndown, Dunraven and Bridgend Beds. Read before the Cotteswold Club, Nov. 16th, 1884, by W. C. Lucy, F.G.S.

In the Autumn of 1867 the Cotteswold Club met at Bridgend, and under the able guidance of our President, Dr Wright, Mr Etheridge, Mr Chas. Moore and the Rev. W. S. Symonds spent two days in examining the sections of the district, in order to form an opinion of the position of the beds, which had been rather warmly contested by Messrs Moore, Tawney, Duncan, and Bristow; and the result of the investigation is recorded as follows, in the President's able address for March 1868 (Volume IV, 1866-68.)

"The Grey beds, forming the so-called Southerndown series, immediately underlie the Bucklandi beds, and are themselves an abnormal development of the zone of *Ammonites angulatus*, which fossil is found throughout, of all sizes from that of a crown piece to that of a small cart wheel.

"At the base of these beds, immediately above the White Sutton-stone, was found *Am. Johnstoni*, the ribbed representative of *Am. planorbis*, and probably marking the same horizon. The White Sutton beds were considered by a majority of those present to represent the White Lias, though Mr Moore insisted strongly on their true Liassic character, and was certain he had taken *Am. angulatus* in situ, out of these beds; but the most searching investigation failed, upon the present occasion, to establish that point."

In July, 1883, accompanied by Mr Thos. Slatter and Mr R. F. Tomes, we spent eight days in the district, making our quarters first at Bridgend, and afterwards at Southerndown.

Mr Tomes suggested the excursion, as he was anxious to re-examine the beds, which he had visited two or three times before, once with Mr Moore, and with the special object of collecting Corals, and to see what Palæontological evidence they would give on the subject of this debateable area, and which he has since shown, in an exceedingly carefully written paper, communicated to the Geological Society on the 19th of March, 1884, which is published in the *Quarterly Journal* for August in the same year; and his views, I am glad to find, are in accordance with my own observations.

We took with us the papers of Messrs Moore,* Bristow,† Tawney,‡ Duncan,§ and Tate,‖ carefully reading them on the spot, and we arrived at the conclusion, with the exception of Tate's, (which is purely Palæontological) they were rather too controversial, and that the Geology had yet to be satisfactorily worked out.

I first visited the beds near to the Railway Station at Bridgend, which show a great development of Lower Lias, and in Mr Moore's section he has divided them into 476. In three places the Clinometer gave the dip to be 23° 20° and 17° to the south east. Saw a large *Am. sauzianus;* and when with the Club in 1877, it was from this section I found the fine specimen of *Am. angulatus*, which is now in the Ammonite case at the Gloucester Museum.

Mr Tawney has certainly fallen into an error in describing this section as Middle Lias, as it clearly belongs to the Lower Lias beds.

The next day by train to Cefn Station, and from there walked over a high ridge of Millstone Grit, and descended on the other side to the Stormy Cement Works, a distance of about two miles. The surface the whole way was fairly covered with large boulders of the same formation.

* *Quart. Journ. Geol. Soc.*, Vol. XXIII, p. 449, 1867.
† " " " " Vol. XXIII, p. 199, 1867.
‡ " " " " Vol. XXII, p. 69, 1866.
§ " " " " Vol. XXIII, p. 12, 1867.
‖ " " " " Vol. XXIII, p. 305, 1867.

The beds in this Section are most important, as giving the key to explain the coast sections, and show a good exposure from the Keuper Marls to the *Planorbis* and *Johnstoni* beds; and I believe the Conglomerate is the same bed as is seen at the coast. (*See Section A.*)

Mr Bristow admits at p. 204 of his paper that the lowest bed but one represents the White Lias. The fracture of the stone resembles the Estheria bed, but both belong to the Rhætic series. This Section is so important that I cannot forbear, at the risk of repetition, from giving an extract from Mr Tomes's paper:—

"The regular succession of the lower beds of the Lias and the upper ones of the Rhætic formation is very clearly shown. The Conglomerate takes exactly the place *beneath* the Ostrea-beds, and, if I am right in my determination, the precise position *above* the Estheria beds which is proper to the White Lias or its admitted equivalent. At any rate the mere fact of its occurrence under beds which cannot be otherwise than the Ostrea beds must be taken as indubitable evidence of its position below the Hettangian series of beds. My own conviction is that the Conglomerate bed is the true representative of the Sutton-stone of Sutton and West, of the Guinea bed of Binton and Grafton, in Warwickshire, and of the White Lias of that county and the west of England. A comparison of the Section at Stormy with the lower part of the Section I have elsewhere given of the Binton Lias* will show how considerable is the resemblance between the two."

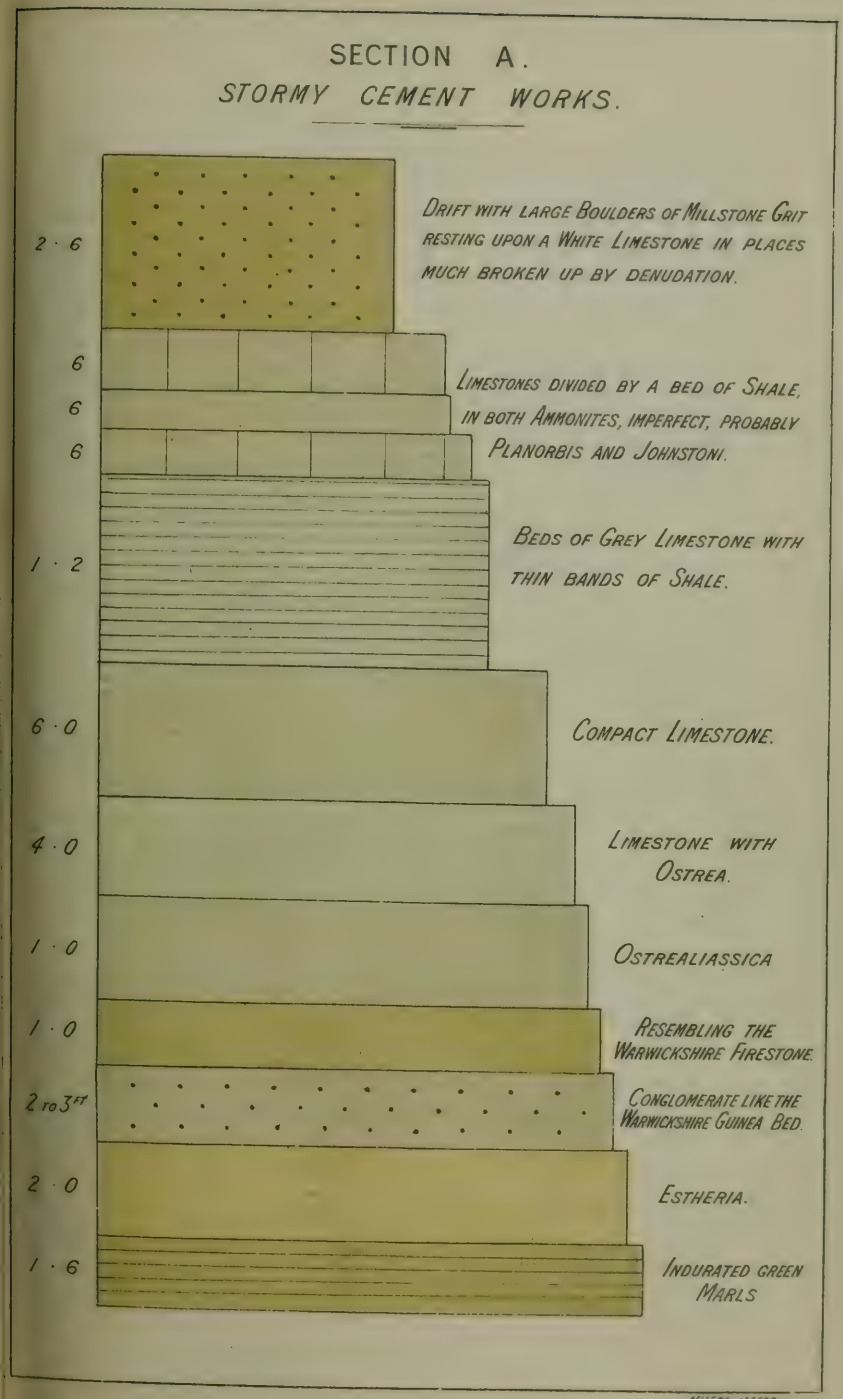
Walked on to Lalestone, and saw a considerable quantity of drift on the surface of the ground. The boulders were still of Millstone grit. In the churchyard there is a small quarry mentioned by Mr Moore, and which is now nearly filled up with rubbish. The upper beds belong to the Ostrea series, and I found in them *Ostrea liassica*. Underneath are the Conglomerate beds, again showing they are below the Hettangian series. About half way from Lalestone to Bridgend, near the toll-bar, is a quarry in the Bucklandi beds, which will well repay examination.

Brocastle is clearly marked on the map on the road from Bridgend to Cowbridge, but the quarry is some distance from the few houses which form the village, and I had some difficulty in finding it. Mr Tomes visited it with Mr Moore, and thought

* *Quart. Journ. of the Geol. Soc.*, Vol. XXXIV, p. 182.

SECTION A.

STORMY CEMENT WORKS.



BELLCHS, LEASDS.

a good deal had been since taken away. It is on the slope of a small hill rising about eighty feet above the flat ground of Lias, and rests upon the Mountain Limestone, but it was clear to my mind that it was merely a large mass of drift; indeed it has that appearance in Mr MOORE's figure, page 521, *Quart. Journ.*, Dec., 1867. Thence to St. Mary's Hill Common. It was a long time before we could find Termydd, which lies a little west of the Common, to which we were at last directed by the Clergyman, two of whose parishioners we had before asked, but they were both so deaf that we could not make them understand. It is referred to by Mr BRISTOW, page 204, as containing Sutton stone, and as beds intermediate between the ordinary Lias and Carboniferous Limestone. He gives the dip as 25° in a direction west of south. I confess I could not satisfy myself as to the position of these beds.

On to Paulline, and from there walked to Cwrt, near which are the old lead mines, and in a wood near the Rhætic shales come up to the surface. On the way back to Bridgend, at Tythegstone, there is a quarry in the grounds of the Rev. G. KNIGHT, which appears to be Dolomitic Conglomerate.

About a mile and a half from Bridgend is Angleton, where there is a quarry, out of which the new Lunatic Asylum, close to, was built. There are cappings of Millstone Grit drift, and underneath are some apparently Rhætic shales: then comes the building stone, which Mr TAWNEY regarded as the base of the Keuper, but which BRISTOW says represents the upper part of the Rhætic, and explains (in p. 205 of his paper) that "the replacement by Sandstones of the ordinary Calcareous and muddy sediments of which the Rhætic series is generally composed indicates here a coast-line and shallow water," but without expressing a definite opinion, I am inclined to accept Mr TAWNEY's view.

Crossed the Ogmore by the bridge, and on returning to Bridgend, passing along the bank of the river, in the bed the Rhætics are again seen, and within half a mile of Bridgend is the Quarella quarry, the top covered with a thick bed of drift, underneath which are Rhætic shales of about three feet,

succeeded by a hard good building stone like that at Angleton, fully thirty feet thick, and the lower part is used for grindstones. These beds certainly seem to belong to the Keuper.

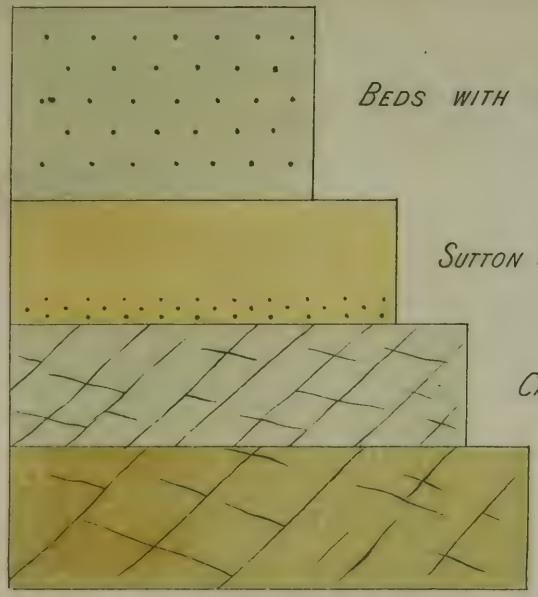
Left Bridgend for Southerndown, and proceeded from thence to Sutton. Near the point where the Sutton stone ends, before getting on the Mountain Limestone, found a very fossiliferous bed, seven feet from the surface, very compact, and apparently near the bottom, as we could only get five feet below it, containing in great abundance *Elysastræa fischeri.* It had all the character of a reef, and many of the corals were converted into Carbonate of Lime. In the bed underneath they also occur, but not to the same extent. *Pecten Suttonensis* abounded in both beds, and *Ostrea interstriata* was fairly abundant; also some lead and Chalcedony.

At Dunraven Point, about half way round the corner east, there is an arch, showing, in a very instructive manner, the Conglomerate resting on the Mountain Limestone, with which in some places it is intermixed; and a short distance further on nodules of the Limestone occur in the Conglomerate. A line of fault is afterwards seen, which appears to pass through or near where the Castle stands, and when the fault is down on the coast the beds become very deceptive, and what at first sight appears to be the Conglomerate is altered Lias, with Conglomerate in it. It much resembles the Sutton stone Conglomerate, which Messrs Bristow and Tawney considered it to be; it also contains nodules of Carboniferous Limestone. From some of the Lima beds large blocks have fallen on the shore, showing four courses like jointed masonry, as distinctly as if the several layers were laid by masons. The true position of the junction of the Conglomerate and the Lias is best seen in a cave just west of a shake in the beds, and, owing to it, the Lias beds are brought down and occupy a lower position than the Conglomerate; hence I believe the reason of some discrepancies in the reading of the beds by some who have described them.

Having examined the Sutton stone from west of Sutton to a point east where we could not proceed further, owing to the then

SECTION B.

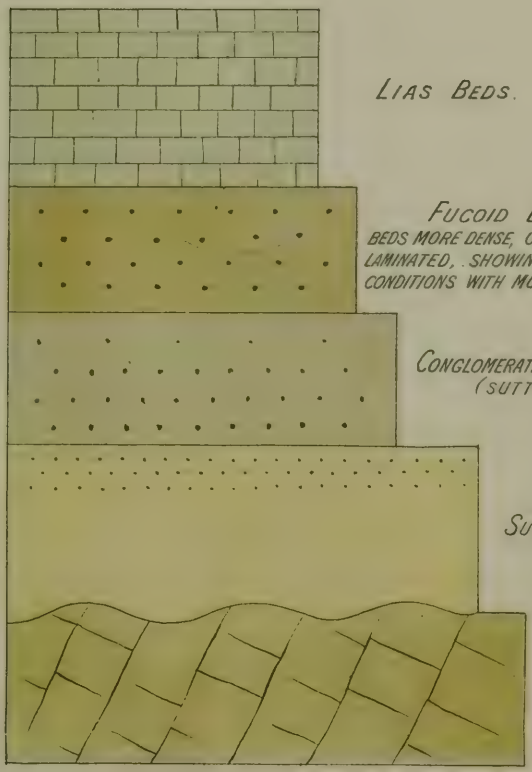
WEST OF THE CAVES.



BELLOWS, 154503

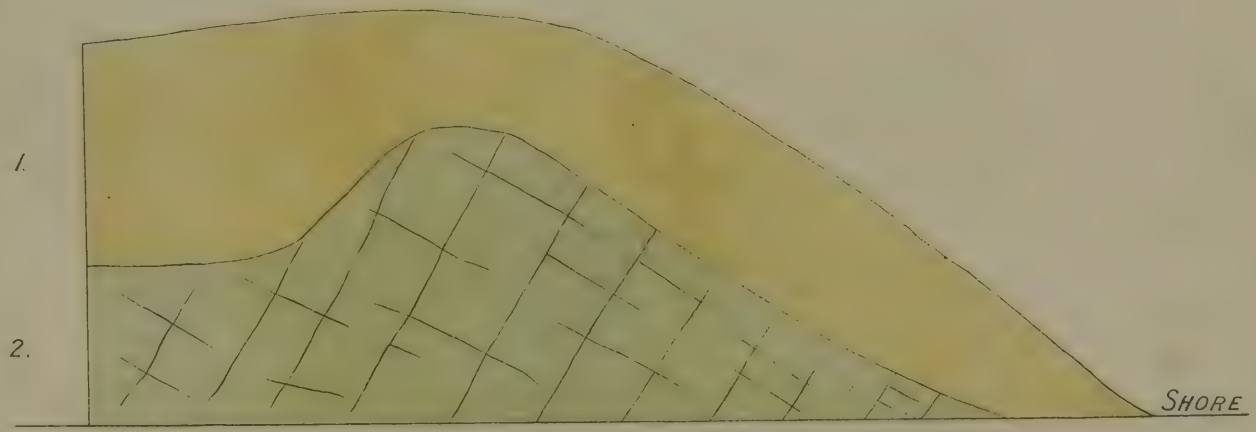
SECTION C.

NEAR TO THE CAVES WEST.



SECTION D.

30 YARDS WEST OF GREAT CAVES.



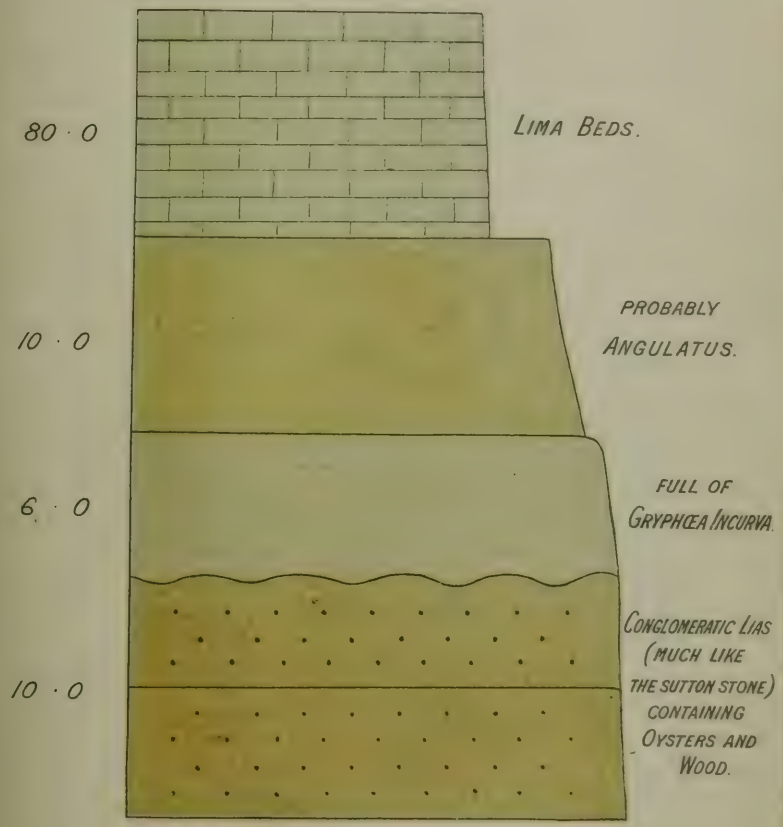
1 SUTTON STONE.

2. CARBONIFEROUS LIMESTONE.

BELLOWS. 134515

SECTION E.

HALF WAY FROM THE CAVES TO THE ROAD FROM DUNRAVEN TO THE SHORE.



BILLCMS, 154503

state of the tide, we selected low water to fill up the gap from there to the caves, and thence eastward to the opening of the Combe near Dunraven. (*See Section B*, west of the caves.)

A little further to the west from there is a remarkable bed of brownish clay stone, which, when I first saw it, I took to be Rhætic, as it looked much like the beds in Ogmore river, north of Bridgend. The bed above and below is Carboniferous Limestone, and I found in it a fossil of that formation,—another instance of how deceptive the beds are in this area.

Now proceeding eastward, near the west of the cave is *Section* marked *C*, which is important, as showing so well the position of the fucoid bed, a very marked horizon. Further on there is a section where the Sutton stone has overlapped the Carboniferous Limestone, and comes down to the shore; it occurs thirty yards west of the centre of the opening to the Great Cave. (*Section D.*)

East of the cave is an upheaval or mass of Carboniferous Limestone, and I observed, as we went more eastward, the beds become greyer and more Conglomeratic, (Southerndown series) and which seems to me to be owing to the old sea having washed over, denuded, and carried forward what was once a high surface of Carboniferous Limestone. There is a very marked change in the condition of the beds east and west from this point. Now a great difficulty occurs in tracing the beds eastward, owing to the change of dip and slight faults or shakes in the cliff.

About half way between the caves and the road from Southerdown, which comes down to the shore at Dunraven, the Lias beds dip at a considerable angle from the cliff, and at low water are down on the shore; and this has, I believe, caused error on the part of some writers on the subject, not being able to distinguish and follow the beds, and consequently not seeing their true position, they might readily be mistaken for Sutton stone. (*See Section E.*)

On a careful examination of the bottom bed the colour is found to be darker than it appears at first sight, and when broken it shows its true Liassic character.

I agree with Mr Bristow that you cannot separate Sutton stone and Conglomerate, in the way Mr Tawney has done it, and also that the measurements of thickness by the former are accurate, viz. 35 to 37 feet. I made it 36, while Mr Tawney shows 89·9. I cannot, however, bring my mind to consider the lower series of Sutton stone west of the caves as true Lias, and I believe it represents the White Lias, and that the lower bed at the Stormy Cement Works is the same. We certainly found neither *Ammonites* nor *Gryphœa incurva* in it. There were many sections of shells which might be mistaken for them, but we believed they were probably *Ostrea irregularis*. The *Pecten Suttonensis* and *Ostrea interstriata* abounded, and higher up I found a good *Modiola*, much like those occurring at Westbury cliff.

With regard to the evidence of the beds as furnished by the corals in the long list of Madreporia which Mr Tomes has made in his communication to the *Quarterly Journal of the Geological Society*, and which, with his permission, I have given at the end of this paper, it will be seen that nearly all the species hitherto determined from the White Lias are also St. Cassian species, the only exception being *Montlivaltia Rhætica* and the branching *Thecosmislia* from Long Sutton; also that a certain number of St. Cassian and White Lias are common to those formations and to the Sutton stone, but that none of them occur in the Brocastle Conglomerate. Furthermore a most important difference will be observed between the coral faunas of the Sutton stone and Brocastle, not a single species being common to both.

Palæontological evidence of the age of the Sutton stone would, no doubt, be conclusive, if no uncertainty existed respecting the precise spot from which the fossils were obtained, but the difficulty of collecting them, excepting corals, and the doubt as to their position, owing to the diversity of opinion of the several collectors respecting the definition of the Sutton stone proper, diminishes very greatly the value of their evidence.

Mr Tomes mentions in his paper in the *Quart. Journ.*, p. 361, "that Mr Moore has expressed the opinion that a great thickness of Conglomerate exists below the Sutton stone. This, he

believed, might have been accumulated contemporaneously with Liassic beds elsewhere. Furthermore he has made the remarkable statement that the shaft of the Langan lead mine was sunk, first through beds of fine Conglomerate, afterwards through the Sutton stone, and then to a depth of 150 feet into an unstratified Conglomerate, the bottom of which was not reached. This latter was supposed by Mr MOORE to be identical with beds observed by him under the Sutton stone in the coast section. Bearing this statement in mind, I made a most careful examination at Sutton, but could not perceive the least evidence of any deposit in the position indicated by him. What Mr MOORE observed at cave No. 2 (see page 528 of his paper) was, I believe, nothing more than a part of the Sutton stone itself, which, as Mr BRISTOW observes, 'becomes hard and blue near that place.'"*

What I believe has led to great misapprehension in working out the beds is that the Lias Conglomerate has been taken for the Sutton Conglomerate, an error which could readily be made from the peculiar position of the beds along the shore.

In the Section D, thirty yards west of the caves, it will be seen how the Sutton stone falls over a dome of Carboniferous Limestone and dips underneath the sea. Now near the caves the beds are shown fairly in sequence, and, as Mr TOMES mentions of the beds forming the upper two-thirds of the Section, that their lower limit is clearly defined by the fucoid bed mentioned by Mr BRISTOW, and by the line of fragmentary chert noticed both by him and Mr TAWNEY, but that No 2, although very decidedly Conglomeratic, is unquestionably true Lias, and that it contains characteristic Lias fossils.

Going from the east, about half way from the caves to the road from the Dunraven Arms leading to the shore, the bottom

* The statement made by Mr MOORE, and here alluded to by Mr TOMES, is certainly a very remarkable one, and the more so as one object of Mr MOORE's paper was to show that the Sutton stone was nothing more than ordinary Lias, altered by contact with Mountain Limestone. Yet here we have one hundred feet of Conglomerate interposed between it and that formation, and its lithological character, for anything we are informed to the contrary, fully preserved.

beds are Conglomeratic, and in appearance much resemble the Sutton stone. They are Lias; and I believe they have been mistaken for the Sutton stone, and many of the supposed Sutton stone fossils were probably taken out of these beds. I think it likely it was from these beds that Mr Charles Moore found *Am. angulatus*, a form he well knew, and which he was not likely to mistake; but he may have made an error in the formation, which here is certainly deceptive.

It is of course of paramount importance in the interpretation of this interesting coast section that the exact stratigraphical position of the Sutton stone, so peculiar lithologically, as well as palæontologically, should be made clear; and in addition to what has already been said in favour of its similarity in so many respects to the upper Rhætic beds, we may remark that we believe there is very direct stratigraphical evidence of its lying below all those beds exposed in the section. If we take a position when the tide is out, immediately in front of the cliff, and far enough away to take all in from Sutton to the road leading from Southerndown to the shore, we shall see that all the beds east of the caves, from top to bottom, dip eastward and pass out of sight. West of the caves the dip is the same in all the upper beds, but less distinct in the lower or Sutton Stone beds; yet it may be traced in the lower ones too, and a little reflection will show that one of three alternatives must be accepted. Either the Sutton stone is conformable with the overlying Lias, and is inclined at the same angle with it,—or it must thin out very rapidly to the east and present a wedge-shaped mass,—or, if it does not dip eastward, it must be wholly uncomformable with the overlying Lias. That the Sutton stone, as Mr Moore supposed, passes horizontally into the Conglomerate, and thence into the true Lias, is only possible when the beds of all are horizontal also; and we know that they are not. And as there is not the slightest evidence of the thinning out of the Sutton stone, or of its being uncomformable with the beds above, we can only conclude that it occupies a perfectly normal position below the Lias, and with it dips to the east, and is speedily lost sight of.

In conclusion, I am deeply sensible of presuming to differ from many former writers of much greater knowledge than myself, but it is the privilege of science—and without it the number of new discoveries would be limited—not to blindly accept authority when it appears to be at variance with your own observations; and I would respectfully suggest to the Director of the Geological Survey that he should send one of his staff, wholly unconnected with the controversy, to carefully work out the beds, keeping an accurate record of the fossils found in each, which would set at rest the true position of these much disputed beds.

Mr Tomes' list of the Madreporia of the White Lias, Sutton Stone, Brocastle Conglomerate, and of the St. Cassian beds.

	St. Cassian	White Lias	Sutton Stone	Brocastle
Montlivaltia capitata	✪			
" obliqua	✪			
" recurvata	✪			
" acaulis	✪			
" crenata	✪			
" perlonga	✪	.....	✪	
" radiciformis	✪			
" granulata	✪			
" cellulosa	✪			
" Walliæ	.....	.....	.....	✪
" simplex...	.....	.....	.....	✪
Omphalophyllia gracilis	✪			
" boletiformis ...	✪			
" cyclotiformis ...	✪			
" deformis	✪			
" pygmæa	✪			
Peplosmilia triassica	✪			
Calamophyllia cassiana	✪	.....	✪	
Rhabdophyllia recondita	✪	.....	✪	
Thecosmilia Hörnesii...	✪	✪		
" Zietenii	✪			
" granulata	✪			
" rugosa	✪	✪	✪	
" confluens	✪	✪		
" irregularis, *Laube* ...	✪			
" neglecta	✪			
" major	.....	.....	.....	✪
" suttonensis	.....	.....	✪	
" mirabilis	.....	.....	✪	
" serialis	.....	.....	✪	
" Terquemi	.....	.....	.....	✪
" Brodiei	.....	.....	.....	✪
" dentata	.....	.....	.....	✪

	St. Cassian	White Lias	Sutton Stone	Brocastle
Thecosmilia Duncani, *Tomes* (= irregularis, *Duncan*) ...	.....	.....	.....	o
" from Long Sutton ...	.....	o		
Cladophyllia subdichotoma	o	.....	o	
" sublævis	o	.....	o	
" gracilis	o			
Isastræa sinemuriensis	.....	.....	.....	o
" globosa	.....	.....	.....	o
" Gümbelii	o	.....	o	
" Haueri	o			
" splendida	o			
Latimæandra Bronni	o			
" labyrinthica	o			
" plana	o			
Stylina Reussi	o			
Elysastræa Fischeri	o	.....	o	
Stylastræa sinemuriensis	.....	.....	.....	o
" Martini	.....	.....	.....	o
" plana	.....	.....	o	
" gibbosa	.....	.....	o	
" reptans	.....	.....	o	
" parasitica	.....	.....	o	
" insignis	.....	.....	.....	o
" pedunculata	.....	.....	.....	o
" dendroidea	.....	.....	.....	o
" minuta	.....	.....	.....	o
Cyathocœnia decipiens	o	.....	o	
" dendroidea	.....	.....	.....	o
" incrustans	.....	.....	.....	o
" costata	.....	.....	.....	o
Astrocœnia Oppelli	o			
Microsolena ramosa	o			
" plana	o			
" , sp.	.....	.....	o	
Septastræa excavata	.....	.....	.....	o

On the Forest Marble and Upper Beds of the Great Oolite, between Nailsworth and Wotton-under-Edge. By E. WITCHELL, F.G.S.

The country situate between Nailsworth and Wotton-under-Edge has hitherto received little attention from Cotteswold Geologists.

LYCETT, in describing it in the "Geology of the Cotteswold Hills," selects, as an example of its Geology, the large quarry on the summit of Wotton hill, which, he says, "yields stone fitted for rough walls and road mending, but shells are absent"—that "there are occasional layers of fine shelly detritus, together with single plates and spines of *Echinoderms* joints of *Pentacrinites*, and, rarely, the teeth of fishes." That similar Sections are met with commonly over the plateau of the Great Oolite between Bath and Minchinhampton. "Oolitic Limestones, forming beds of no great thickness, destitute of clay or marl partings, and without a trace of organic life, are commonly met with."

This description always appeared to me so unattractive that for a long time I thought that an examination of the rocks exposed would not probably lead to the discovery of anything of an interesting or instructive character to reward me for my trouble, consequently I have never until recently examined them, nor am I aware that any member of the Club has done so since LYCETT wrote his book. In fact when the Club, a few years ago, went over a portion of the ground to visit Calcot Barn, two quarries at Tiltup's End were passed by, as they were not supposed to contain anything worth halting to examine,

but I am now inclined to think that there are few Geological Sections in the Cotteswolds that will not repay the observer for the time he may spend in their exploration, and the quarries at Tiltup's End are examples in point.

Recently, in company with two of our colleagues, Mr Chas. Playne and Mr Alfred Smith, of Nailsworth, I went over the ground between Nailsworth and the top of Wotton hill. Our object was chiefly to see if there was sufficient material for a programme of one of the Summer meetings of the Club. The result of our examination, so far as it relates to the Geology of that part of the Cotteswolds, is contained in the following notes, which I have put together, thinking that they might be interesting to the Geologists of the Club.

The area which I have mentioned is shown on the map of the Geological Survey as occupied by the Forest Marble and Great Oolite. In the neighbourhood west of Kingscote the Forest Marble occupies the high ground, but in that locality the two formations resemble each other so closely on the surface that it is not easy to trace the boundary lines without the aid of the Map. The White Limestone of the Great Oolite in that part of the area nearer to Nailsworth is more distinctive. These Limestone beds, which constitute the upper part of the Great Oolite, have their greatest development in the neighbourhood of Sapperton Tunnel, where they have a thickness of twenty feet, and they are probably very little thinner as they approach Minchinhampton. Dr Wright describes them briefly in his paper on "The Correlation of the Jurassic Rocks of the Côte D'or with those of the Cotteswolds;" he mentions them as occurring at Minchinhampton, Cowcombe, and Sapperton, but does not allude to their extension south-westward beyond Minchinhampton.

Dr Lycett gives a full description of the Limestone, and speaks of it as passing through the village of Avening and the Minchinhampton district, but he does not appear to have traced it in the direction of Wotton-under-Edge. This has now been done, and it is found to gradually thin out in that direction, and to disappear near Kingscote.

The first quarry on the hill south-west of Nailsworth is on the Bath road at Tiltup's End. The following is the Section :—

No.	ft.	in.	
1	2	0	—Surface rubble.
2	7	0	—Beds of Forest Marble, fissile near the top, but thicker and more regularly bedded beneath. Some of the beds appear as if they had been originally consolidated in thick blocks, but had subsequently split into thin beds. These beds are composed of sand, lime, and shelly detritus, highly crystalline, and of a greyish white in colour. They contain few fossils. The upper beds are more Oolitic, and light brown in colour.
3	0	4	—Marly and sandy band, in places replaced by reddish clay. (In the next quarry described this band is highly fossiliferous.)
4	4	0	—White Limestone (Great Oolite) in thick beds ; some parts are white and chalky, others are very hard, having a conchoidal fracture, and varying in colour from white to a pale straw or creamy white. It contains in its upper part numerous fossils, in a highly cyrstalline condition. The fossils include some large examples of Nerinæa. The base of the beds is not exposed.

At the distance of about 300 yards in the direction of Calcot Barn there is another quarry, now disused, in which the Forest Marble has been denuded, so that the White Limestone is within three feet of the surface, and is about seven feet thick. The upper stratum of the Limestone contains three or more species of Nerinæa, one species in large numbers. They occur in a layer about six inches thick, which is almost made up of these shells, but *Terebratula maxillata*, and *Lima* (sp) are moderately abundant; a coral, *Isastrea Beesleyi*, is also common; small lumps covered with *Bryozoa* are also abundant. The presence of Nerinæa in such profusion is somewhat remarkable, especially as in the quarry first mentioned the thin band between the Limestone and Forest Marble beds does not contain any fossils.

The Limestone beds may be seen in small sections between Tiltup's End and Kingscote. In a small quarry near Lasborough it forms the surface rubble, and probably thins out at no great distance beyond. In a road-side quarry south of Kingscote its thickness can be measured, and it appears to be only 10 inches; beneath is the shelly bed of the Great Oolite. In the larger

quarry, now disused, two miles beyond, towards Wotton-under-Edge, it does not appear, and has thinned out altogether. I believe it does not again occur in that direction. It may also be remarked that when the Club visited Beverstone Castle some time ago, it was noticed and recorded that the Limestone beds had thinned out in that direction also, as no trace of them could be found in the Great Oolite quarry near Beverstone.

The following fossils have been found by me in the White Limestone at Tiltup's End. Those marked with an asterisk were found only in the Nerinæa bed:—

Brachiopoda.

*Terebratula maxillata, *Sow.*
*Waldheimia ornithocephala, *Sow.*
Waldheimia bullata, *Sow.*. var.

Gasteropoda.

*Nerinæa Voltzii, *Desl.*
——— complicata, n. ap.
——— intermedia, n. sp.
——— simplex, n. sp.
——— n. sp.
——— (Trochalia) Eudesii, *M. & L.*
Cerithium, casts of
*——— quadricinctum, *Gold.*
*——— sp.
Alaria trifida, *Phil.*
Nerita hemisphærica, *Rœm.*
Natica, sp.
Acteonina Luidii, *Mor.* (qy.)
Purpuroidea, fragments of
*Amberleya, sp. "
*Phasianella conica, *M. & L.*
Monodonta Labadyei, Archiac sp.

Conchifera.

Cardium pes-bovis, *D'Arch*
Lucina bellona, *D'Orb.*
——— subglobosa, nov. sp.
*Pecten arcuatus, *Sow.*
——— vagans, *Sow.*
Lima Cotteswoldiensis, n. sp.
Cyprina Loweana, *M. & L.*
*Ostrea costata, *Sow.*
——— sp.
*Isocardia minima, *Phil.*

Echinodermata.

Echinobrissus clunicularis, *Wr.*

Anthozoa.

Serpula socialis
*Anabacia, sp.
*Isastrea Beesleyi

It may be here remarked that Lycett, in his description of the White Limestone, speaks of it as upon the whole remarkably

destitue of organic remains, but he mentions two exceptions, first, the Pachyrisma bed at Bussage and Cowcombe, at the base of the Limestone, in which that shell, two species of *Natica*, and two of *Purpuroidea* are abundant,—and secondly, a single locality east of Minchinhampton, where the uppermost bed of the series, described as a sandy buff-coloured rock, contains *Pholadomya socialis*, *Lucina Bellona*, *Ceromya concentrica*, *C. Symondsii*, *C. undulata*. *Cyprina Loweana*, *Purpuroidea Morrissii*, *P. nodulata*, *Nerita rugosa*, *Nerinæa funiculus*, *Alaria armata*, *A. paradoxa*, *Cardium pes-bovis*, and *Goniomya litterata*, in greater or less abundance. It is singular that our *Nerinæa* bed, which is exactly on the same horizon, contains a larger assemblage of shells, but all except two, or at the utmost three, are of different species. The existence of these beds of fossils on the same horizon but some five miles distant from each other, suggests the probability that other like assemblages occur in the surrounding neighbourhood, and that the close of the Limestone period was marked by an accumulation of shells in patches on the floor of the Oolitic sea, constituting a zone of life not altogether identical with that of the period of the shelly Weatherstones, which preceded the formation of the Limestone.

A mile beyond Tiltup's End, on the Bath road, and near Calcot Barn, there is a small quarry, used for obtaining road-stone. It is about ten feet deep, of which the lower five feet consist of thick compact beds, which at first sight somewhat resemble the White Limestone, but on closer examination they are found to differ in structure and colour, and are identical with the lower beds of Forest Marble at Tiltup's End. The formation is coloured "Forest Marble" on the Geological Survey Map. From the resemblance of these beds to those at Tiltup's End I have no doubt that they occupy a similar position, and that the White Limestone is beneath. It confirms the opinion I have before expressed that the Forest Marble of this area was originally thick bedded and not fissile, as it is usually seen in the neighbourhood of Cirencester.

All the fossils in these beds are either in the form of casts or are so highly crystalline as to defy almost every effort to

extract them. An accidental fracture may expose the internal structure, or the external surface of part of a shell, which may possibly with very great care and patience be cleared. In this way I obtained a very fine specimen of a *Trigonia*, belonging to the *undulatæ*. I consider it to be a variety of *T. undulata*, as it differs in form from that shell, as described by LYCETT in the monograph of the *Trigoniæ*, published by the Palæontographical Society. It is much higher in comparison with its breadth, and has a narrower area and more curved umbones than is shown in the published figures, and is much larger in size. (Plate IV., fig. 6.)

The shelly Weatherstones of the Great Oolite do not appear on the surface in the area under description. They occur in the greater part of the Cotteswolds, and come next to the White Limestone, which they underlie. They extend beyond the margin of the Limestone area in almost every direction. At Minchinhampton Common they are about fifteen feet thick. At Tiltup's End the Section is not sufficiently deep to expose them, but they may be seen in the road-side quarry near Kingscote, as before mentioned, where they appear to have become less shelly, except the upper two feet, which contain a fair assemblage of shells. Here they agree with a similar bed in the village of Nympsfield, half a mile south of Frocester hill, where there is a small section of Great Oolite, containing a shelly bed, three feet thick. A mile west of Kingscote, on the Wotton-under-Edge road, the beds are well exposed in a large road-side quarry, but they are no longer shelly, as at Minchinhampton; a few fossils, chiefly small valves of Oysters, occur, but the character of the beds is that of a rock composed of shelly detritus Oolitic granules and sand.

At the Ridge, and not far from the top of Wotton hill, is the quarry probably alluded to by Dr LYCETT, whose description of the rock as quoted above, is perfectly accurate. The shelly beds therefore may be described as commencing west of Kingscote, and a line drawn from thence to Frocester hill will sufficiently indicate their western extremity. Possibly they did not quite thin out at this line, but owing to the denudation of

the Uley valley and the escarpments of Frocester hill and Uley Bury, no trace of the shelly Great Oolite can now, so far as I am aware, be found to the south-westward of the line. The beds gradually increase in importance towards Minchinhampton Common, where the typical section is seen. From thence they extend eastwards through the hills north and south of the valley of the Frome at Chalford, and finally dip under the White Limestone in the Edgeworth valley.

From the circumstance of these beds merging into Weatherstones, composed chiefly of sand and shelly detritus, it seems probable that the shells were originally deposited not far from a shore, and were ground up into fine detritus, which was spread over a large area, and eventually consolidated into the Weatherstones, as described by Lycett.—that another large deposit of shells took place, under conditions more favourable to their preservation, as will appear from an examination of the shelly beds of Minchinhampton Common, but even in these favoured areas the conditions ultimately changed, as is shown by the condition of the shells found in the planking beds, which are usually worn, and appear to have undergone much rolling before they were finally deposited. Other evidence of the proximity of land is seen in the abundance of plant remains in the Weatherstones, as well as the Forest Marble, throughout the area I have described.

The break between the White Limestone and the overlying beds is well defined in the Sections at Tiltup's End, and the occurrence of a layer of fossils in two localities just at the line of junction—the beds above and below not being very fossiliferous—followed by a change in the character of the deposits from a pure fine-grained chalky Limestone to a coarse sandy rock, made up of shelly detritus, sand, and Oolitic granules, points to a period of cessation of deposits, followed by a change of conditions, and probably of elevation of sea bottom. The Geological Surveyors were therefore right in making this horizon the line of separation between the Great Oolite and the Forest Marble, although this line is now considered merely as one of sub-division; and the Forest Marble is more usually regarded as a member of the Great Oolite series.

DESCRIPTION OF THE SPECIES FIGURED

Lucina subglobosa, n. sp. Pl. IV., fig. 1

Shell orbicular, globose, umbones tumid, mesial, curved, hinge margin nearly straight, oblique, lunule moderately large, concentric folds regular, nearly flat, having fine longitudinal striations. The thickness through both valves is equal to two thirds of the lateral diameter, height and breadth each ten lines.

The concentric folds resemble those of *Lucina Bellona*, D'Orb., with which it is found, and it may possibly be a variety of that species, but it is very much smaller, is more globose in comparison with its diameter, and is destitute of the oblique obscure elevation from the umbones to the inferior and posterior border, which is one of the characteristics of that species.

Locality.—Tiltup's End, near Nailsworth, in the White Limestone (Great Oolite.)

Nerinæa complicata. n. sp. Pl. IV., fig, 2, 2a

Shell very long, slender, conico-cylindrical, upper whorls concave, ornamented with five transverse minute ribs; the lower whorls gradually become flatter and smooth—the last few whorls thickened at the suture, which gives a slight convexity to the whorls. Columella solid, with three folds, the anterior fold bifurcated, the anterior branch of the bifurcation angulated, or slightly bifurcated; the middle fold angulated, the posterior fold bifurcated, there is also a small fold, sometimes scarcely visible, on the posterior wall. The outer wall has three principal folds, the upper or posterior fold is simple, the middle fold is sharply angulated and broad at the base; the anterior fold is also broad, and is more produced anteriorly. There is also a minute fold between the upper and middle principal folds; aperture sub-quadrate; length about five inches. The diameter of the whorls is slightly greater than the height.

The external characters of this shell resemble those of *Nerinæa implicata*, D'Orb., and the internal characters approximate closely to those of that shell, as also to *N. bacillus*, D'Orb., and *N. Trachea*, Desl.; they do not however quite agree with those species. In *N. implicata* and *N. bacillus* the posterior fold on the outer wall is broad and angulated, in *N. complicata* it is narrow and rounded at the end. The fold next below, which is almost obsolete in *N. complicata*, is acute and deep in the two other species; the anterior fold is bifurcated in *N. complicata*, in the other species it is angulated only. There are also differences in the folds on the columella; in *N. complicata* the posterior fold is strongly bifurcated, in the other species it is merely angulated; the middle fold is angulated, in *N. bacillus* it is a round knob, larger than its base. *N. trachea* differs in having simple folds on the columella, and the posterior fold on the outer wall bifurcate.

Locality.—Tiltup's End, near Nailsworth, in the Great Oolite, where it is abundant.

Nerinæa (Trochalia) Eudesii. Pl. IV., fig. 3, 3a, 3b, 3c

Nerinæa (Trochalia) Eudesii, Mor. & Lyc., G. Ool. Mon. Pl. 7, fig. 6

This shell is figured and described by Morris and Lycett, the figure drawn is that of a young form. It is described as turreted, conical, excavated, whorls (ten) concave, narrow, with numerous transverse lines, sutures carniated, carniæ elevated and smooth, base flattened, canal short, aperture sub-quadrate. It is said to be rare. The internal characters were not fully known to the authors, but as far as they could observe them they described the outer lip as simple, the columella plicated with one fold, and the upper portion of the volution having a very slight fold.

The external description given is correct, but Morris and Lycett's figure bears slight proportion, as regards size, to the adult shell, which cannot be less than seven inches in length. The internal structure as described is inaccurate. The shell has a columella imperforate, with a blunt rounded fold upon it,

rather below the middle of the volution; the outer wall has a large conical acute fold at the middle of the volution; the slight fold referred to on the upper portion of the volution is doubtful.

Locality.—Tiltup's End, near Nailsworth, in the White Limestone (Great Oolite.)

N. calcarea see p. IV a this volume

NERINÆA SIMPLEX, n. sp. Pl. IV., fig. 4, 4a.

Shell smooth, conico-cylindrical; whorls flat, numerous, the height equal to two-thirds of the diameter, sutures moderately deep; columella perforated; outer wall with one small mesial fold; there is also a small fold in the posterior wall.

This shell is closely allied to *Nerinæa gracilis*, LYC., but is more conical, the whorls are much greater in diameter as compared with their height, the fold on the posterior wall also distinguishes it from that species.

Locality.—Tiltup's End, Nailsworth, in the White Limestone (Great Oolite.)

NERINÆA INTERMEDIA, n. sp. Pl. IV., fig. 5, 5a, and Pl. V. fig. 1, 1a.

Shell conical, volutions smooth, flat, suture slightly shown; aperture elongated, terminating in a channel, which is somewhat lengthened and curved backward; columella perforated, having one acute conical fold anterior to the middle of the volution; on the wall one deep blunted fold; on the posterior wall one deep acute fold. Length of adult specimen four to five inches.

Although specimens of this shell are exceedingly numerous in the *Nerinæa* bed, it is difficult to obtain them otherwise than in fragments, and the best examples are somewhat worn on the surface, and are not sufficiently well preserved to enable me fully to show the external character of the species.

Locality.—Tiltup's End, near Nailsworth, in the *Nerinæa* bed, between the Great Oolite and Forest Marble—abundant.

Nerinæa Voltzii, *Desl.* Pl. V., fig. 3.

This shell is believed to be a full grown example of *N. Voltzii*, but in consequence of its crystalline condition its internal structure cannot be ascertained, it must therefore be judged only from its external appearance, but it differs only in size from some of the examples of that species from Minchinhampton. If this view be correct, it would seem that the shells figured by D'Orbigny and Morris and Lycett were immature forms; the specimen now figured is many times larger than either of those figured by the authors named.

Locality.—Tiltup's End, near Nailsworth, in the *Nerinæa* bed, between the White Limestone and Forest Marble.

Nerinæa. sp. Pl. V., fig. 2, 2a.

Shell elongated, conico-cylindrical, volutions nearly flat, their height one-fourth less than the diameter; suture sub-obsolete, aperture nearly quadrate, outer lip angulated, channel small, curved backward, height probably four inches.

The form of the aperture distinguishes this species from *N. intermedia*, with which it is associated; there are traces of ornamentation upon the surface, in the form of encircling lines. The internal character is unknown. Having found only one fragment of this shell, I defer naming it until further specimens have been obtained.

Locality.—Tiltup's End, near Nailsworth, in the White Limestone (Great Oolite.)

Nerinæa ? dubia, n. sp. Pl. V., fig. 9, 9a.

Shell small, acute, volutions (eight) ornamented with very faint encircling lines, the last volution equal to two-fifths of the entire length, aperture small, sub-quadrate, channel slightly curved.

This shell may perhaps be only a young example of *Nerinæa;* its crystalline condition prevents an examination of its internal structure. It may possibly be a *Cerithium.*

Locality.—Bussage, in the Great Oolite.

CERITHIUM BUSSAGENSIS, n. sp. Pl. V., fig. 5, 5a, 5b.

Shell small, inflated, sub-cylindrical, volutions (seven) convex, having perpendicular ribs, narrow, slightly curved, crossed by four encircling costæ, the posterior of which is crenulated, the others elevated, giving a rough appearance to the surface; there are additional costæ round the base, suture deep, aperture nearly circular.

Locality.—Bussage in the Great Oolite.

CERITHIUM COTTESWOLDIENSIS, n. sp. Pl. V., fig. 8, 8a.

Shell small, sub-cylindrical, volutions (seven) convex, ornamented with very numerous oblique ribs, which disappear on the anterior part of the volution; each volution has six encircling lines; suture deep; aperture ovate; canal short.

The large number of ribs will readily distinguish this from contemporaneous species.

Locality.—Bussage, in the Great Oolite.

PHASIANELLA CONOIDEA, n. sp. Pl. V., fig. 6, 6a.

Shell small, smooth, conical, spire acute, volutions (five) flattened, the last volution inflated and slightly angulated near the middle, aperture ovately rounded; height four lines.

The outline of this shell is more angular than is usual in this genus, by which feature and by its more rounded base it is distinguished from *P. parvula*, M. & L., to which it bears some resemblance.

Locality.—Bussage, near Stroud, in the Great Oolite.

CHEMNITZIA SPARSILINEATA, n. sp. Pl. V., fig. 7.

Shell turreted, spire regular, elevated, volutions concave, transversely costated, costæ widely separated, longitudinally striated; striæ faintly marked, suture deep, aperture nearly round.

This shell may be readily distinguished from contemporaneous species by its general aspect. The costæ are fine lines, five on the penultimate volution; the height of each volution is rather less than the diameter. In the only example discovered the upper part of the spire is broken off, its height cannot therefore be determined, but it is probably about nine lines.

Locality.—Bussage, in the Great Oolite.

TRIGONIA UNDULATA, FROM. var. PLAYNEI, *Witc.* Pl. V., fig. 6.

Shell sub-ovate, erect, convex, umbones curved and bent forward, area convex, crossed by transverse plications, marginal carina nearly obsolete; median furrow without carina; rows of costæ numerous, moderate in size, tuberculated, tubercles distinct on the upper rows of costæ, more obsolete on those below; costæ irregular over the lower half of the shell. Compared with the examples of this species figured by LYCETT (Brit. Foss., *Trigoniæ*, Pl. XVI, figs. 9, 10, 11, and Pl. XVII, figs. 5, 6,) this shell is more erect, larger and more convex; the umbones are much more curved. Its length in proportion to its diameter is as four to three, whereas LYCETT's figures are nearly as wide as long. These differences are considered sufficient to constitute this shell a variety of *T. undulata.*

Locality.—Calcot, near Kingscote, from the lower beds of the Forest Marble (abundant.)

I have named this shell after my late esteemed friend and colleague G. F. PLAYNE, deceased, who was an indefatigable member of the Cotteswold Club, and the author of several valuable papers which appear in the Transactions.

LIMA COTTESWOLDIENSIS, n. sp. Pl. V., fig. 4, 4a, 4b.

Shell tumid, nearly upright, umbones sub-mesial, ribs (52 to 54) regular, rounded, moderately elevated, but nearly obsolete in proximity to the umbones, the diameter equal to the interstitial spaces, which are striated, striæ rather closely arranged,

auricles moderately large and obliquely striated; lunule excavated; height two and a quarter inches, diameter two inches, thickness through both valves 17 lines.

This shell differs from *L. cardiiformis*, Sow., in being more equilateral and upright, more tumid, and the ribs more regular. In outline the figure approaches *L. impressa*, Lyc., but the ribs are quite different. There is a *Lima* in the lower beds of the Freestone in the Inferior Oolite as yet undescribed, which seems to be closely allied to this shell, but it has smaller ribs and is slightly more oblique.

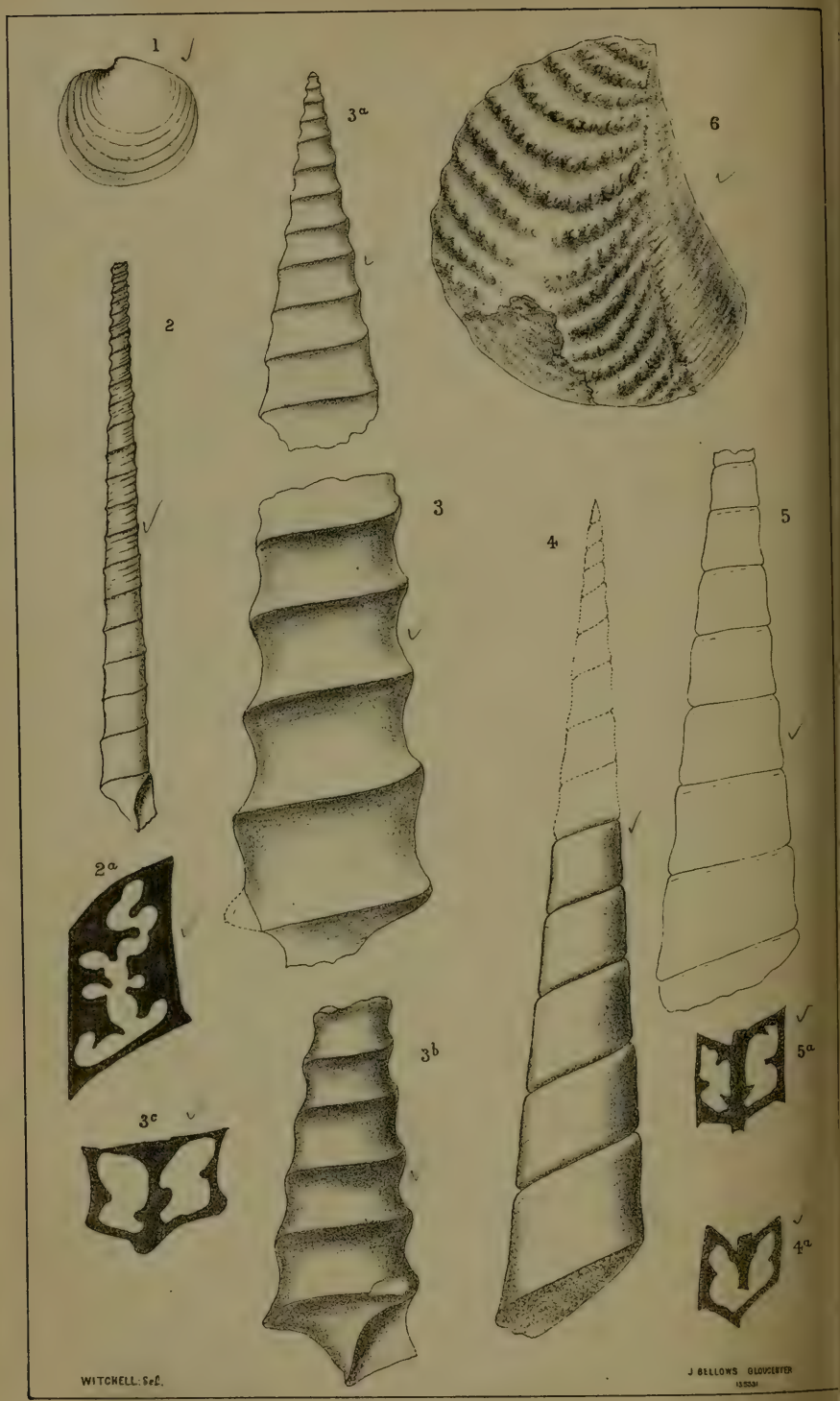
Locality.—Tiltup's End, near Nailsworth, in the White Limestone, (Great Oolite) and in the overlying Nerinæa bed, where it is somewhat rare.

Addendum to the description of Fossils from the Clypeus Grit of the Inferior Oolite. Vol. VII., page 128.

Nerinæa Guisei, *Witc.*, Pl. V., fig. 10, 10a, and Vol. VII., Pl. IV., fig. 2a, 2b, 2c.

I have found a fragment of this shell which, though not well preserved, indicates the character of the aperture, which may be described as sub-quadrate, widening at the termination, the outer lip having a sharp angle; channel small. The specimen now figured shows that in the young forms the relative height of the volution to the diameter is greater than in a more advanced stage of growth. Fig. 10a shows the internal characters more clearly than they are represented in the previous figures.

PLATE 17.



EXPLANATION OF THE PLATES.

Plate IV.

1. Lucina subglobosa, n. sp., natural size. Great Oolite, Tiltup's End, near Nailsworth. (Page 272.)
2. Nerinæa complicata, n. sp., natural size. Great Oolite, Tiltup's End. (Page 272.)
2a. „ „ section magnified.
3. „ (Trochalia) Eudesii, *M. & L.*, natural size. Great Oolite, Tiltup's End. (Page 273.)
3a. „ „ „ another example, natural size.
3b. „ „ „ another example, showing the aperture.
3c. „ „ „ section of the interior of one of the volutions.
4. „ [= Calcarea simplex,] n. sp., natural size. *Nerinæa* bed, Great Oolite, Tiltup's End. (P. 274.)
4a. „ „ section of the interior.
5. „ intermedia, n. sp., natural size. *Nerinæa* bed, Great Oolite, Tiltup's End, and Pl. V., fig. 1, 1a. (P. 274.)
5a. „ „ section of the interior.
6. Trigonia undulata, *From.* var. Playnei, natural size. Forest Marble, Calcot. (P. 277.)

Plate V.

1. Nerinæa intermedia, n. sp., natural size. *Nerinæa* bed, Great Oolite, Tiltup's End, near Nailsworth. (Page 274.) and Pl. 1, fig. 5.
1a. „ „ section of the interior.

2. NERINÆA n. sp., natural size. *Nerinæa* bed, Great Oolite, Tiltup's End. (Page 275.)

2a. „ „ section of the interior.

3. „ VOLTZII, *Desl.*, natural size. Great Oolite, Tiltup's End. (Page 275.)

4. LIMA COTTESWOLDIENSIS, n. sp., natural size. Great Oolite, Tiltup's End. (Page 277.)

4a. „ „ side view of same.

4b. „ „ portion of the costæ.

5. CERITHIUM BUSSAGENSIS, n. sp., natural size. Great Oolite, Bussage. (Page 276.)

5a. „ „ another view of same.

5b. „ „ volution enlarged.

6. PHASIANELLA CONOIDEA, n. sp., enlarged. Great Oolite, Bussage. (Page 276.)

6a. „ „ another view of same.

7. CHEMNITZIA SPARSILINEATA, n. sp., enlarged. Great Oolite, Bussage. (Page 276.)

8. CERITHIUM COTTESWOLDIENSIS, n. sp., natural size. Great Oolite, Bussage. (Page 276.)

8a. „ „ volutions magnified.

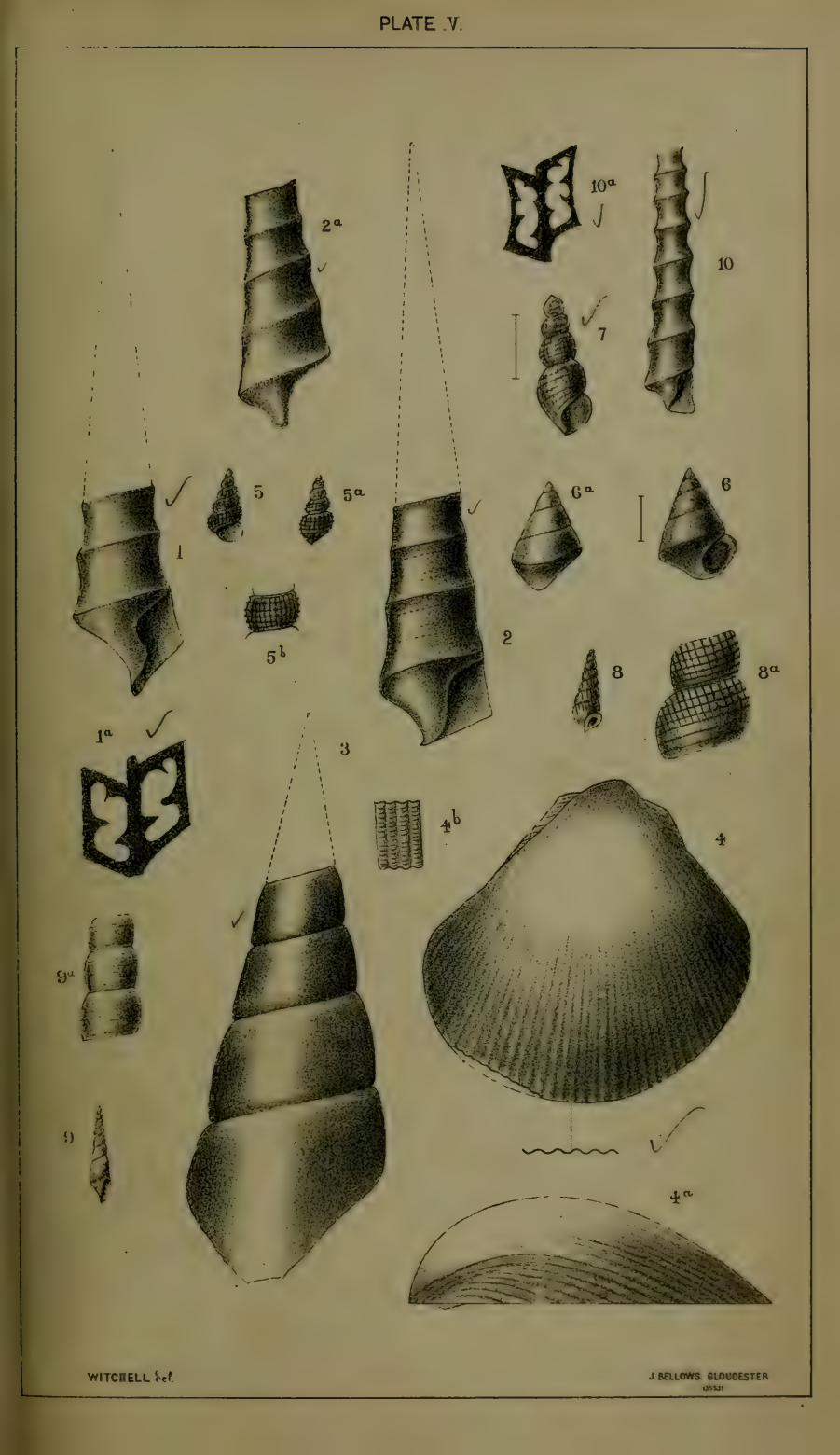
9. NERINÆA ? DUBIA, n. sp., natural size. Great Oolite, Bussage. (Page 275.)

9a. „ „ volution magnified.

10. „ GUISEI, *Witc.*, natural size. Inferior Oolite Rodborough. (Page 278.)

10a. „ „ section of interior of another example. (Slightly enlarged.)

PLATE V.



WITCHELL del.

J. BELLOWS. GLOUCESTER

On the Structure and Formation of certain English and American Coals, read at a Meeting of the Cotteswold Club, on Tuesday, February 3rd, 1885. By E. WETHERED, F.G.S., ETC.

Much has been written on the subject of the structure of coal since DE LUC, in the years 1793—5, contended that it was the product of vegetation which grew on the spots where the seams are now found. To do justice to the researches of HUTTON, Sir JAMES HALL, MC CULLOCK, GÖPPERT, Sir WILLIAM LOGAN, CARRUTHERS, WILLIAMSON, HUXLEY, NEWTON, DAWSON, PRESTWICH, BINNEY, REINSCH, BRONGNIART and others, would be to compile a volume. I must therefore confine myself to brief references to those points which are material to the present paper.

An important addition to our knowledge of the question was given by Sir WILLIAM LOGAN in 1840, when he pointed out that under every seam of coal there was a stratum of clay, called the underclay, in which a fossil vegetable, *Stigmaria ficoides*, was always to be found. Later on Mr BINNEY discovered this vegetable to be the root of the Carboniferous genus *Sigillaria;* and it is now generally regarded as the root of the Lepidodendroid plants generally. Accepting then the views of DE LUC, in conjunction with the discovery of *Stigmaria* and its relations, it was assumed that seams of coal were formed by the submergence of forests of *Sigillariæ* and *Lepidodendra*, with, perhaps, other forms of terrestrial vegetation. Thus GÖPPERT,* after examining the coal-fields of Germany, remarks that "many seams are rich in *Sigillariæ, Lepidodendra* and

* Quart. Jour. Geol. Soc., Vol. V., Mem. p. 17.

Stigmariæ, the latter in such abundance as to appear to form the bulk of the coal. In some places almost all the plants were *Calamites* or other ferns."

Sir WILLIAM DAWSON, of Montreal, who stands second to none as a specialist in Carboniferous Geology, referring to the plants which have contributed the vegetable matter of the coal says,* "these are principally the *Sigillariæ*, with *Cordaites* Ferns, and *Calamites*. With these, however, are intermixed remains of most of the other plants of the period, contributing, in an inferior degree, to the accumulation of the mass. This conclusion is confirmed by facts derived from the associated beds, as, for instance, the prevalence of *Stigmariæ* in the underclay, and of *Sigillariæ* and *Calamites* in the roof-shales and erect forests." Mr CARRUTHERS expressed his views on the subject in the course of some remarks on a paper which I read at the Geological Society during the early part of this year.† "Coal-seams," said Mr CARRUTHERS, "are the remains of forests which grew upon swampy ground, and were subsequently covered by clay." The views as expressed by GÖPPERT, DAWSON and CARRUTHERS, are fairly typical of those generally entertained on the subject of the origin and formation of coal. In 1870, however, Professor HUXLEY announced in the pages of the *Contemporary Review* that coal was simply the sporargia and spores of certain plants, other parts of which have furnished the carbonized stems and the mineral charcoal, or have left their impressions on the surface of the layer. This, however, was not the first time that the spores of plants had been detected in coal. Professor MORRISON, in a note appended to Mr PRESTWICH's paper‡ on the Geology of Coalbrook Dale, called attention to the occurrence of what he considered to be spore cases of plants in coal. The late Professor J. H. BALFOUR noticed similar bodies, and referred to them in the Transactions of the Royal Society of Edinburgh for 1854, and in the same volume Professor J. H. BENNETT figured sections of coal in

* Acadian Geology, 3rd Edition, p. 471.

† Quart. Jour. Geol. Society, Vol. XL., p. 60, Proc.

‡ Geol. Trans., 2nd Ser., Vol. V.

which spores are present. Mr CARRUTHERS, too, refers to them in the Geol. Mag. for 1865, page 433; but the first person who noticed the occurrence was the late Dr FLEMING.

Without wishing in the least to lessen the value of the investigations of some of the observers just referred to, it is necessary to understand on what basis they arrived at their conclusions. Professor HUXLEY examined the coal microscopically, the sections having been cut by Mr E. T. NEWTON, F.G.S. Sir WILLIAM DAWSON's method was to examine the mineral charcoal by a process described on page 494 of his very able and valuable work on Acadian Geology. Specimens of coal were selected containing the tissue of only a single plant. These were boiled in strong nitric acid, and after the fumes had subsided the residue was washed and submitted to microscopic examination. Next, as to Mr CARRUTHERS's source of information, if I understand him correctly, there are in the British Museum a number of mud balls, said to have been derived from seams of coal. In these Mr CARRUTHERS finds the remains of Carboniferous forest growth; and he assumes that therefore the seams of coal have been formed by like vegetation to that preserved in the mud balls.

Let us now test the above sources of information. Professor HUXLEY's is, I contend, the only reliable one. If a transparent section of true coal can be obtained, nothing can disprove what it reveals. But even this method may lead one astray if the investigation be only partial. Sir WILLIAM DAWSON pointed this out to me, and suggested my preparing microscopic sections from various positions in a seam. I adopted this hint, and am much obliged for it: the results will be presently stated. Sir WILLIAM DAWSON's method of treating selected specimens with nitric acid is, in my opinion, liable to mislead as to the general structure of the coal. First, I object to the principle of specially selecting a piece of coal for examination; if we detect a fragment in a seam better preserved, with regard to structure, than the rest of the mass, the very fact should invoke caution, as there must be a cause for the preservation. It may be due to the fragment being a

foreign element, (foreign, I mean, so far as the general mass of the coal is concerned) which has resisted decay better than the mass of vegetation which has formed the deposit. Second, when coal is treated with nitric acid dense fumes come off, this implies that something is undergoing destruction, and the importance of the loss is only known when we obtain microscopic sections. Sir WILLIAM DAWSON has, however, figured* well preserved portions of tissue, obtained by the nitric acid process; but whether all can be regarded as the tissue of the coal-forming plant is, I think, uncertain. Sir WILLIAM DAWSON, with his usual candour, admits that two difficulties have impeded his investigations, "and have in some degree prevented the attainment of reliable results." "One of these," he says, "is the intractable character of the material as a microscopic object; the other the want of sufficient information with regard to the structure of the plants known by impressions of their external forms in the beds of the coal formation." Then as to Mr CARRUTHERS. In my opinion the evidence on which he relies can only be regarded in the light of circumstantial evidence, and by no means clearly proves what Mr CARRUTHERS claims for it. Take, for instance, a modern peat bog. The vegetation which has mainly contributed to it are the bog-mosses (*Sphagnaceæ.*) Growing in the bog, however, are to be found conifers and other vegetation. Suppose such a bog to be submerged, as bogs sometimes are, what would be the result? The vegetable mass would undergo decay, it would pass from peat to lignite, and thence to coal. If it were worked in the distant future, the Geologists and miners of the period would doubtless find the remains of conifers and of other vegetation, but if the deduction were drawn that, because these remains could be recognised, that therefore the coal originated from that form of vegetable growth, then a very wrong idea would be gathered as to the main origin of the mineral. I may add that it is by no means improbable that coal seams may not have originated in some such manner as peat.

* Acadian Geology, 3rd Edition, p. 464.

I will now proceed to record my own investigations, and will take first the Shallow Seam of Cannock Chase, South Staffordshire. For the stratagraphical section and information concerning the seam I am indebted to Mr A. H. Barnard, of Chase Town.

SECTION OF THE SHALLOW SEAM.

Description	Ft.	In.	Structure
"Harders" or Top Bed. Dull lustre, with occasional bright layers	1	10	Dull layers, chiefly a mass of microspores and macrospores, with wood tissue in bright layers.
"Upper Spire	0	2	A Carbonaceous argillaceous parting.
"Bright Coal," or middle bed. Bright lustre throughout	0	9	Brown structerless hydrocarbonaceous material, with occasional microspores and macrospores.
"Lower Spire	0	2¼	Carbonaceous arenaceous parting.
"Best Coal," or bottom bed. Dull and bright lustrous layers	4	3	Hydrocarbon, macrospores and microspores; the two latter chiefly in the dull layers.
Underclay			Argillaceous bed, with Stigmaria.

This seam is divided by partings into three distinct beds of coal. In the top one, called "Hardens Bed," two layers could be very clearly defined, a bright and a dull. In the latter minute specks were detected, somewhat resembling iron rust. By polishing a portion these specks were distinguished as macrospores, Figs. 1 and 2, and a microscopic action showed the spaces around and between them to be filled with countless numbers of microspores, Fig. 3. In the bright layer of the "Hardens" spores were also detected, but were much less numerous, and there was also present, as the chief constituent, a brown structerless material to which I have given the name hydrocarbon. Vegetable tissue was also recognised.

Between the top and middle beds of the seam came a carbonaceous parting locally termed "Spire," and in which was a considerable quantity of pyrites. The middle, or "Bright Coal," is a true cannel. It readily polishes, and when this is done a few macrospores may be distinguished. A microscopic section shows the presence of microspores, but they were scarce, compared to the quantity in the upper bed. The main mass of this coal was made up of the material which I referred to under the name of hydrocarbon, and before proceeding further it may be as well to say something respecting this substance. It is generally structerless and presents a dark brown appearance. It is an important constituent in the structure of some coals; the so called bituminous varieties being the richest in the possession of it. I believe it to consitute that which has erroneously been termed bitumen. I need, however, hardly say that coal contains no bitumen whatever, and the sooner we strike such a misleading term, as applied to coal, out of our vocabulary the better.

Below the "Bright Coal" is a second parting of "Spire," with an arenaceous stratum running through the centre.

Next comes the "Best Coal," or bottom bed, which is the chief one of the seam. The lustre is fairly bright which appears to be due to the numerous thin bright layers which travers the dull portion. In the dull layers macrospores and microspores were numerous, but in the bright hydrocarbon was the chief constituent.

The variations in the beds which constitute the "Shallow Seam," illustrate the importance of investigators taking a complete stratagraphical section of each seam to which they turn their attention. The top bed is not a freely combustible fuel, but when combustion has fairly commenced considerable heat is generated. The "Bright Coal" is mainly worked for gas purposes, and the "Best" for gas and household use. A mixture of the "Hardens" and "Best" beds makes an economical house coal, but requires a good draught.

I next take the Welsh "Four Feet Seam," celebrated throughout the world for its smokeless properties. For samples

and permission to inspect the seam underground I am indebted to the owners, (Messrs Geo. Insol & Son.) and to the manager of the Cymmer Colliery, near Pontypridd, South Wales. At this Colliery the "Four Feet" presents the following section:—

SECTION OF THE FOUR FEET SEAM, CYMMER COLLIERY, NEAR PONTYPRIDD, SOUTH WALES.

Description	Ft.	In.	Structure
Top Bed. Coal brittle, with bright lustre	2	0	Carbonized vegetable tissue, with a little hydrocarbon.
Argillaceous Parting	1	0	Minature underclay. Stigmaria (?)
Middle Bed. Medium lustre	4	6	Highly carbonized vegetable tissue.
Argillaceous Parting	0	5	Minature underclay.
Lower Bed	2	0	Close under the parting well preserved scalariform tissue. Sections from the centre showed numerous spores, spore cases and structerless vegetable tissue.
Argillaceous Parting	0	2	Stigmaria
Bottom Bed	1	6	Inferior Coal, not worked.
Underclay	4	0	Stigmaria.

From the fact of this seam being termed the "Four Feet" persons may be led to regard it as four feet of Coal only; that, however, is not the case. The above section shows the seam to be made up of four distinct beds. The lowest one, unfortunately, I have not had an opportunity of examining. The top bed of all is mainly a mass of carbonized vegetable tissue, with a little hydrocarbon, but the coal was so brittle that no very satisfactory slides were mounted, though a fair idea of the structure was gained during the process of endeavouring to prepare them. The bed, four feet six inches thick, following in descending order, is the chief one of

the seam; it may be said to be a mass of highly carbonized vegetable tissue, with a small proportion of hydrocarbon. The structure of the next bed is most interesting, and was clearly defined in the microscopic sections made of it. At the top, just under the parting, sections showed well preserved scalariform tissue, (Figs. 5 and 6). Lower down a number of small spores, (Figs. 4 and 37) were found. Very little of the material was carbonized, but was either in the form of or passing into hydrocarbon.

The "Four Feet" is a further illustration of the necessity of taking stratagraphical sections of the seams of coal to be examined when attempting to ascertain the structure. If this be not done very imperfect information may be gathered.

It was while submitting the microscopic sections of this last seam to Sir William Dawson that he suggested to me that possibly important results might be obtained by the microscopic examination of a seam in different parts. An opportunity of this was afforded me by Mr Woodhead, colliery manager to the Low Moor Iron Company, near Bradford, Yorkshire, who, by the kind permission of the Company, sent me a portion of the "Better Bed" coal intact for a thickness of ten inches from the top; I therefore determined to examine it inch by inch. I was fortunate in the selection of this seam, as it has been rendered famous by Professor Huxley, who from it deduced what may be termed the spore theory for the formation of coal. The section of the seam, as sent me by Mr Woodhead, is as follows:—

SECTION OF THE "BETTER BED" SEAM OF COAL,
LOW MOOR IRON COMPANY'S COLLIERY,
NEAR BRADFORD, YORKSHIRE.

	Ft.	In.	
Shales			
Coal (Laminated)	0	$3\frac{1}{2}$	1 ft. 10 in.
Coal	1	$6\frac{1}{2}$	
Seat Stone (Underclay)	1	0	

The lustre of the first three and a half inches at the top was dull, the remainder, with the exception of a layer half an inch

thick at four inches from the top, was a medium brightness. In describing my own investigations, I cannot do better than record them as written down at the time of observation.

Within the first two inches from the top.—Mainly made up of macrospores and microspores, somewhat similar to those detected in the "Harders" bed of the "Shallow Seam" of Cannock Chase, (Figs. 7, 8, 9, 10). Well preserved scalariform tissue detected.

Three inches from the top.—Spores less numerous. Some of the macrospores have caudate appendages. The mass chiefly made up of hydrocarbon and decomposed vegetable tissue.

Four inches from the top.—Spores again numerous, but do not constitute the whole mass. The predominating macrospores (Figs. 12 and 13) show the caudate appendages, and are smaller than the predominating varieties above.

Between four and five inches from the top.—Spores less numerous. Vegetable tissue appears, generally carbonized. Hydrocarbon contributes largely to the composition of the whole mass.

Between six and seven inches from the top.—Spores form but a small proportion of the whole coal; it is mainly made up of tissue and hydrocarbon. Carbonized scalariform tissue was met with, the first I have noticed in that state of preservation.

Eight inches from the top.—Spores scarce, though they were searched for by cutting horizontal and transverse sections. The coal was made up chiefly of tissue in various stages of decomposition. Some of it appeared to yield a resinous material. The structure here exhibited is the first I have noticed of the kind.

Nine inches from the top.—A few spores noticed. The coal practically built up of tissue and hydrocarbon, the passage of the former into the latter clearly demonstrated. The resinous looking material, noticed above, again present but disappearing.

Ten inches from the top.—Spores few in number; the coal made up of hydrocarbon and tissue. (Fig. 11).

From a perusal of the evidence afforded by the examination of the uppermost ten inches of the "Better Bed," I am

not able strictly to endorse Professor HUXLEY's statements. Undoubtedly the first three inches at the top of the seam is largely made up of spores, but below other vegetable constituents form an important part of the whole. It is also important to note that below the first three inches the spores are, for the most part, apparently of different species to the predominating variety above.

The last English Coal to which I shall draw attention is that of the "Splint Coal" from Whitehill Colliery, near Edinburgh. In the discussion of the paper which I read before the Geological Society of London, on the "Structure and Formation of Coal," one of the speakers said that sporangia were rare in Scottish Coal. Strange to say, Mr JAMES BENNIE, of the Scotch Geological Survey, a few days after the reading of the paper, sent me some specimens of the above Coal, and on examining them, I found spores in great numbers, though it is true no perfect sporangium was found. I therefore wrote to the owners of the Whitehill Colliery, who kindly responded by sending me very good typical samples of the seam. The following is a section sent me by Mr JOHN BEGGS, to which I have added my notes :—

DESCRIPTION	Ft.	In.	STRUCTURE
Splint Coal. Dull lustre, with a few bright layers	1	10	The dull layers a mass of microspores, macrospores and fragments of spore cases.
Rough Coal. Alternation of bright and dull lustrous layers of about the same thickness.	0	10	Hydrocarbon in the bright layers ; a few spores in the dull, of different variety to those below and above.
Splint Coal. Dull lustre, with a few bright layers	0	4	The dull layers a mass of microspores, macrospores and fragments of spore cases.

The "Splint Coal," as worked at Whitehill Colliery, has three distinct beds not, however, separated by partings, as in the case of the "Four Feet" and "Shallow" seam. Microscopic sections of the "Lower Splint" bed show the dull lustrous

portion to be a mass of microspores and macrospores, (Figs. 14, 15, 16, 17 and 18) with numerous remains of spore cases. No sign of tissue was discovered. The bright layers were made up of hydrocarbon, and spores were not detected in them. As the bright layers were thin, a good chance was afforded of testing the doubt as to whether spores did enter into the structure of them. I, therefore, cut a vertical section in which one of the bright layers was bounded on either side by dull ones. On placing it under the microscope spores were numerous on both sides of the bright layer but were not observed in it, they were confined to the dull. (Fig. 21.)

There would appear to be two varieties of macrospores and microspores represented in this coal. The largest variety of macrospore measured about ·047 of an inch in diameter, and a triradiate ridge appears on the surface of some. (Figs. 14, 15, 16.) They are larger than those seen in the "Shallow" and "Better Bed" seams, but in other respects very similar. My attention was first called to the other variety of spores by what I have represented in Fig. 19, where two macrospores, measuring ·003 of an inch in diameter, are seen surrounded by hundreds of minute microspores, measuring ·0005 of an inch in diameter.

The lower bed of the "Splint Coal" is replaced abruptly, and without parting, by the "Rough coal," or middle bed of the seam. The transition in the structure of the Coal is most striking, and deserves careful attention, (Fig. 26.) The "Rough Coal" was made up of two layers alternately one with the other and of about the same thickness (half an inch.) One of these had a bright lustre, the other a medium dull. In the dull layers spores were fairly numerous, but for the most part were a distinct variety to those which appear in the bed below. (Figs. 22, 23, 24, 25.) By far the greater portion of the coal is made up of vegetable tissue and hydrocarbon.

The "Rough Coal" is followed, without parting, by the "Upper Splint" bed. The lustre was dull, and the coal may be said to be practically a mass of macrospores and microspores, and are not all of the same species as those in the Lower Splint. (Figs. 27, 28, 29, 30.)

I now pass to the American coals. The samples which I have examined were not selected for making microscopic sections; they were collected by myself, eight years ago, simply as specimens of American coal. I am, therefore, unable to give the stratagraphical section of the seams from which they were taken. In one way there is an advantage, as it is a guarantee of their being ordinary samples, and in no way selected for the purpose to which they have been turned.

The first coal to which I shall draw attention was taken from the Black Warrior Coalfield of Alabama. And I may here state, by way of parenthesis, that the mineral wealth of that State is but little appreciated. The future of Alabama cannot be otherwise than of great importance. The coal presented a brigh lustrous appearance throughout, though some layers were more lustrous than others. Macrospores and Microspores were present, (Figs. 34, 35, 36, 37) but they did not constitute the whole mass. Vegetable tissue was detected, and a large quantity of hydrocarbon. The Microspores exhibited the triradiate markings before referred to in English coals, and they appeared to be identical with those found in the lower bed of the Welsh "Four Feet," (Figs. 4 and 38.) The Macrospores were not numerous, the most perfect one found is shown in Fig. 34.

The next coal examined was collected near Pittsburg, Pennsylvania. The lustre was bright, and the chief structural constituent discovered was hydrocarbon. Vegetable tissue was also present, some having the appearance presented by decomposed scalariform tissue. Spores were numerous in some layers; these were chiefly microspores, (Fig. 33) resembling those of the "Better Bed," and measuring about ·0015 of an inch in diameter. Macrospores were present, but mostly in a fragmentary state, (Fig. 31.)

Comparing the structure of English and American Coals, the material which I have referred to as hydrocarbon is present in both; the same class of vegetable tissue was detected, and the spores were allied. It is, therefore, clear that some seams of coal in both countries had a common origin—vegetable origin.

The chief points brought out in my observations are—

1st. That some English and American Coals originated from the same class of vegetation.

2nd. Seams of coal do not consist of one continuous bed of the mineral; sometimes the mass is divided into distinct divisions by a stratum of clay, as in the Welsh "Four Feet." At other times the divisions are clearly defined, without clay partings, as instanced by the "Splint Coal" from Whitehill Colliery, near Edinburgh.

3rd. Where a seam is made up of more than one bed, in no case that I have examined have those beds been identical, in a structural point of view.

4th. The dull lustrous layers in some coal may be said to be made up of vegetable spores and spore cases. In the bright layers, and in bright coals generally, spores are much less numerous; in these the material which I have termed hydrocarbon is the chief constituent, associated with vegetable tissue. I have never yet seen a seam built up entirely of spores and spore cases, though certain portions may be.

A knowledge of the structure of coal has a practical value. The occurrence of certain vegetable remains endow the mineral with certain properties; therefore a knowledge of this enables experts to pronounce on a typical specimen submitted to them. For instance, I have made a series of chemical analyses of spore and non-sporous coal. I know the effect upon the mineral of the presence, or non-presence, or scanty presence of spore layers. A pocket lens enables me to detect these bodies if there, and I can thus base certain conclusions on what I see. The same with regard to the occurrence of hydrocarbon. This knowledge is especially useful where a rough opinion is needed.

I now come to another important part of my subject, and it is one which is necessarily somewhat speculative: it is the relation and character of the coal-forming vegetation. Among those who have made the matter a special study is Mr Carruthers, and anything which falls from him deserves careful consideration. In 1865 he published* a paper "On an

* Geol. Mag., Vol. II, 1865, p. 433.

undescribed cone from the Carboniferous Beds of Airdrie, Lancashire," and, referring to the occurrence of spores in coal, says, (p. 434) "not only do these bodies exist in quantity in many coals, but some beds even of considerable thickness are almost entirely made up of them. Their relation, however, to any organism that could have produced them was unknown until the discovery of a cone by Mr JAMES RUSSELL." This cone was submitted to Mr CARRUTHERS, who described it as a new genus under the name of *Flemingites*, and allied it to the modern family of *Lycopodieæ*. It would therefore appear that Mr CARRUTHERS included in this genus all the spores discovered in coal up to that time. It seems, however, that all previous observers had fallen into an error in supposing that the coal-forming plant possessed but one kind of spore, namely microspores. This Professor J. S. BENNETT, in his paper "An Investigation into the Structure of the Torbarehill Mineral and of various kinds of Coal,"* refers to the microspores as "rings of a transparent yellowish or reddish colour, with an opaque centre;"† and, referring to the macrospores, says, "there are also visible circles or rings of a rich golden yellow matter, much larger, and varying in size from the 50th to the 60th of an inch, which have been described by some as seeds or spore cases." His conclusions as to the structure of coal are "that the various organic appearances found in the sections and ashes of coal are explicable by the supposition that coal is wood chemically altered, and for the most part coniferous wood, or wood allied to it in structure." Professor J. H. BALFOUR, in his paper‡ "On certain Vegetable Organisms found in coal from Fordel," mentions the occurrence of seed-like bodies which he considers "to be the sporangia or spore cases of some plant allied to *Lycopodium*, perhaps *Sigillaria*." Later on, in 1872, Prof. BALFOUR refers§ his coal spores, and those which

* Trans. Royal Society Edinburgh, Vol. XXI, p. 173 (185-34.)

† From the plates illustrating Prof. BENNETT's paper I should judge that his sections were not made sufficiently transparent to enable him to judge fairly of the spores and true structure of the coal examined.

‡ Proc. Royal Society of Edinburgh, Vol. XXI, p. 191.

§ Palæontological Botany, description of, Plate III, Fig. 1.

had up to that time been detected in the mineral, to Mr CARRUTHER'S genus *Flemingites*. But what Professor BALFOUR looked upon as a sporangium (Figs. 15, 16, 17, 18, Plate II of his paper) is really not a sponargium but a macrospore, and he has made no mention of the occurrence of the microspores which I have represented in my figures. In describing the genus *Flemingites* Mr CARRUTHERS also fell into the same error, that is to say, he figured it as possessed of but one kind of spore, namely microspores. Like Professor BALFOUR the bodies which Mr CARRUTHERS took for sporangia are really macrospores. The macrospores which I represent in Fig. 19 very closely resemble *Flemingites Pedroans*. Mr CARRUTHERS has himself found out his mistake, and withdrawn the genus, which I cannot but regret, as its re-establishment with fresh description would have prevented the confusion caused by the withdrawal.

It then becomes a question as to whether the coal spores are still to be allied with *Lycopodieæ*, or if not with what? In solving this problem we unfortunately have to deal with imperfect and unsatisfactory information. Several *Lepidostrobi* have been figured and described, some of them containing both kinds of spores. There can be but little doubt the *Lepidostrobi* is the fruit of some *Lepidodendroid* plants, but there is such a variety of forms included under that head that it is not likely those discovered are the only ones which existed. As to which of the individual *Lepidodendra* the known *Lepidostrobi* belong is a matter of doubt, and in support of this assertion I will quote authorities. Mr CARRUTHERS* says, "A cone is very rarely found connected with its supporting branches, the evidence, therefore, of the connection between a *Lepidodendron* and its own Lepidostrobus is consequently of a very unsatisfactory nature." Sir WILLIAM DAWSON says, "I cannot pretend that I have found the fruit of *Sigillaria* attached to the parent stem."† Among those which have been figured I may name *Triplosporites*, which was described by Mr ROBERT BROWN,‡ and

* Geol. Mag., Vol. II, p. 437, 1865.
† Acadian Geology, 3rd Edit., 1878, p. 437.
‡ Trans. Linnean Soc., Vol. XX, p. 469.

which Mr CARRUTHERS looks upon as the Carboniferous representative of *Selaginella*.* The history of this fossil is, very vague. It was brought to this country by a dealer, who had obtained it from the collection of a Baron ROGET, where it had been for about thirty years. Nothing more seems to be known about the fossil, and it is not noticed by Sir JOSEPH HOOKER in his "Remarks on the Structure and Affinities of some *Lepidostrobi*," in the second volume of the Memoirs of the Geological Survey. Other fruits have been figured by BRONGNIART, LINDLEY, HUTTON, BINNEY, Professor WILLIAMSON, and others. The latter was the first to point out the occurrence of both macrospores and microspores in coal, in a paper read before the Geological Section of the British Association at York, but I am not aware that the paper has been printed except in abstract. In the Philosophical Transactions Professor WILLIAMSON figures a *Calamostachis Benneyana*, which shows two kinds of spores. The microspores measure about ·0031, and the macrospores occur as large as .01. However the imperfect specimens figured in Plate LIV, figs. 25 and 26, prevent any reliable comparison, and those figured in the strobilus are not sufficiently magnified to render comparison possible. Professor WILLIAMSON has also found some *Lepidostrobi*, together with ferns and an articulate plant, which he believes to be *Asterophyllites*, and remains of *Lepidodendra* in some remarkable beds in Burntisland, Scotland. The beds occur in the upper part of the Calciferous Sandstones of the Burdiehouse Series, which in stratagraphical position correspond with lower portion of the English carboniferous Limestone. Professor WILLIAMSON states that the beds appear to have been patches of peat, which are now imbedded in masses of volcanic amygdaloid. The general aspect of longitudinal sections of these strobili is that common to *Lepidostrobus*. "They usually have a diameter of from less than half an inch to nearly an inch."† The fruit contains both macrospores and microspores, the latter measuring about ·0007

* Geol. Mag., Vol. VI, p. 298.

† Phil. Trans., 1872, p. 294.

of an inch, and the macrospore figured has a large diameter of ·027. The triradiate feature of the microspores described by Professor WILLIAMSON is common to the coal microspores, and is also shown in those figured by Sir JOSEPH HOOKER in the Memoirs of the Geological Survey.* The absence, however, of macrospores in Sir JOSEPH HOOKER's cones renders an alliance out of the question. With Professor WILLIAMSON's Burntisland strobilus, however, both spores are present. The size of the microspores nearly corresponds with the small variety of microspore detected in the Scotch "Splint" coal, but the macrospores are far too large to correspond with my smaller variety; they more nearly correspond with my larger varieties. Professor WILLIAMSON does not mention anything about a triradiate ridge or marking on the surface of these macrospores, which is a conspicuous feature in those from the coal. He states that the characteristic peculiarity of the macrospores from the Burntisland beds "is the projection from every part of their external surface of numerous caudate appendages." This is a feature common to some of the coal macrospores. In the coal, however, the appendages are not well preserved, and frequently only the roots or base remains, giving to the walls of the spore a tuberculated appearance; indeed I at first took the appearance for tubercles. The appendages are seen in Fig. 13B, where a few of them remain. Professor WILLIAMSON thinks the strobili referred to are the fruit of *Diploxylon*, though he does not appear to have found them attached to the stems of that plant. I would call special attention to Professor WILLIAMSON's remark that the beds in which the remains occur "appear to have been patches of peat."

I cannot say that I am satisfied that the coal spores referred to in this paper are identical with any that have been discovered. I have been told that they are those of *Triplosporites*. Mr CARRUTHERS,† in referring to that genus, points out that the microspores occur in triple form, and, to show the close alliance with the *Selaginelleæ*, he figures the triple microspores of

* Vol. II, Part 2.

† Geol. Mag., Vol. VI, p. 298.

Selaginella spinulosa. This is a feature, however, which I have never noticed in the coal spores, and had it been common to them I should certainly have seen it. I think, however, that coal spores more closely resemble in appearance the *Selaginelleæ* or *Isöeteæ* than to any other class of modern vegetation, but there are now classed by SACH apart from the *Lycopodiaceæ*, under the head of the *Ligulatæ.* Quite recently Professor P. F. REINSCH has figured a number of Carboniferous spores, some of which are closely allied, if not identical, to some of mine, and he gives to them the name *Trileteæ.* In speaking of them he says,* "The *Trileteæ* are spores of *Cryptoganic* plants more highly developed, and if this supposition be correct the *Trileteæ* can only be derived from *Lycopodia* and plants much resembling them. Future investigation will no doubt throw more light on the problem, but one thing seems clear from my investigations, as far as they have gone, namely, that coal originated from one class of vegetation; and I venture to predict it will be found to be of aquatic habit, and that seams of coal originated in a manner not unlike that of modern bog growth.

In concluding this paper I desire to return my thanks to Professor HARKER, of the Royal College of Agriculture Cirencester, for his kindness in helping me examine my slides. He considers that some of the coal spores may be allied to the modern genus *Isöeteæ*, and suggests the generic title of *Isöetoides* pending further investigation.

* Micro-Palaeo-Phytologia. Formation Carbonifera. Introduction, p. iv.

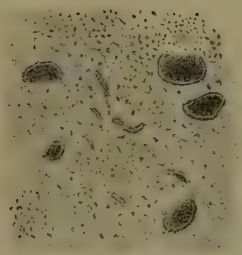


Fig 12
×12½

Fig 13
×50

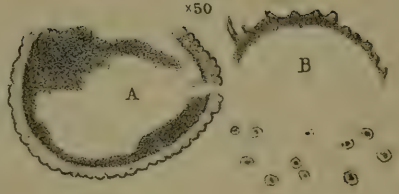
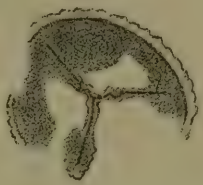


Fig. 14

×22

Fig 15



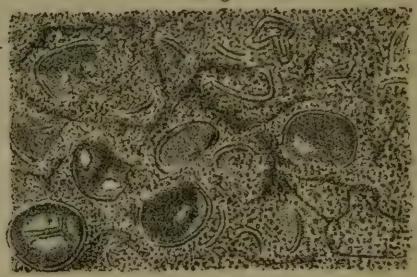
×22

Fig 16

×22

Fig 17
×262

Fig 18



×12½

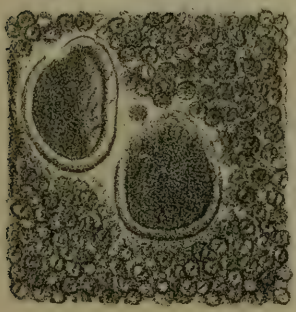
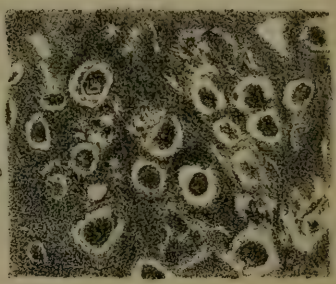


Fig 19 ·262

Fig 20 × 110



THE STRUCTURE OF COAL

E. WETHERED del et nat

PLATE I.

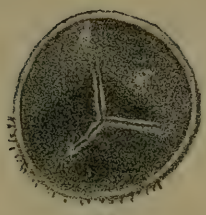


Fig 1
×22

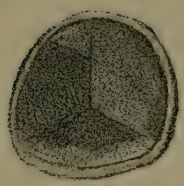
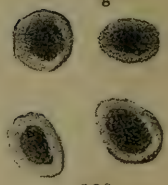


Fig 2
×22

Fig 3



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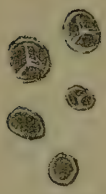


Fig 4
×262

Fig 5 × 12½

Fig 6 ×180

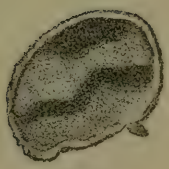


Fig 7
×22

Fig 8
×262

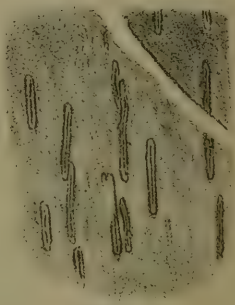
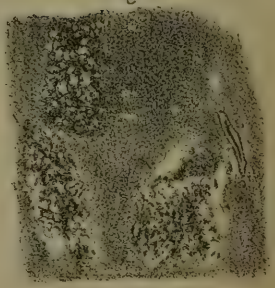


Fig 9 × 12½

Fig 10
×12½

Fig 11 × 12½



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EXPLANATION OF PLATES.

PLATE I.

Figs. 1 and 2.—Macrospores from the Shallow Seam of Cannock Chase, × 22 diam.

Fig. 3.—Microspores from the Shallow Seam of Cannock Chase, × 262 diam.

Fig. 4.—Spores of Plants from about the centre of the lower bed of the Welsh Four Feet Seam, × 262 diam.

Fig. 5.—Horizontal section of the same from the top of the coal close under the "parting," × 12½ diam.

Fig. 6.—Scalariform Tissue from the same, × 160 diam.

Fig. 7.—Macrospores from uppermost three inches of the Better Bed Seam, × 22 diam.

Fig. 8.—Microspores from the same, × 262 diam.

Fig. 9.—Transverse section of the same two inches from the roof of the seam, × 12½ diam. Shows the macrospores, the spaces between them are occupied by microspores and other vegetable material.

Fig. 10.—Horizontal section of the same, × 12½ diam.

Fig. 11.—Horizontal section of the same ten inches from the roof. Shows one macrospore, carbonized vegetable tissue and hydrocarbon, × 12½ diam.

PLATE II.

Fig. 12.—Horizontal section of the Better Bed Seam, four inches from the roof, × 12½ diam.

Fig. 13.—Macrospores and microspores from Fig. 12, × 50 diam.

Figs. 14, 15, 16.—Macrospores from the lowest bed of the Splint Coal from Whitehill Colliery, near Edinburgh, × 22 diam.

Fig. 17.—Microspores from the same, × 262 diam.

Fig. 18.—Horizontal section of the above coal, × 12½ diam.

Fig. 19.—Other macrospores and microspores from the same, × 262 diam.

Fig. 20.—A space between macrospores in Fig. 18, × 160 diam.

PLATE III.

Fig. 21.—Transverse section of the lower bed of Splint Coal intersecting a bright layer between two dull ones, showing the occurrence of spores of plants in the two latter, but not in the bright layer, × 12½ diam.

Figs. 22, 23.—Macrospores from the middle bed of the Splint Coal, × 22 diam.

Figs. 24, 25.—Microspores from the same, × 262 diam.

Fig. 26.—Horizontal section of the coal constituting the middle bed of the Splint Coal, × 12½ diam.

Figs. 27, 28.—Macrospores from the upper bed of the Splint Coal, × 22 diam.

Fig. 29.—Microspores from the same, × 262 diam.

Fig. 30.—Horizontal section of the coal constituting the upper bed of the Splint coal, × 12½ diam.

PLATE IV.

Fig. 31.—Macrospores from coal taken from near Pittsburg, Pennsylvania, U. S., × 22 diam.

Fig. 32—Another spore from the same, with minute spine-like projections on the surface, × 262 diam.

Fig. 33.—Microspore from the same, × 262 diam.

Fig. 34.—Horizontal section of the above coal, × 160 diam., showing microspores and fragment of a macrospore. Should be compared with Fig. 20.

Fig. 35.—Macrospore, in transverse section, from the Black Warrior Coalfield of Alabama, × 160 diam.

Fig. 36.—Microspores from the same coal, × 262 diam. Should be compared with Fig. 4.

Fig. 37.—Other apparent microspores from the same, × 160 diam.

Fig. 38.—Horizontal section the Welsh Four Feet Seam, lower bed, × 160 diam.

Fig. 39.—Horizontal section of Alabama coal, × 160, which should be compared with Fig. 38.

PLATE 3

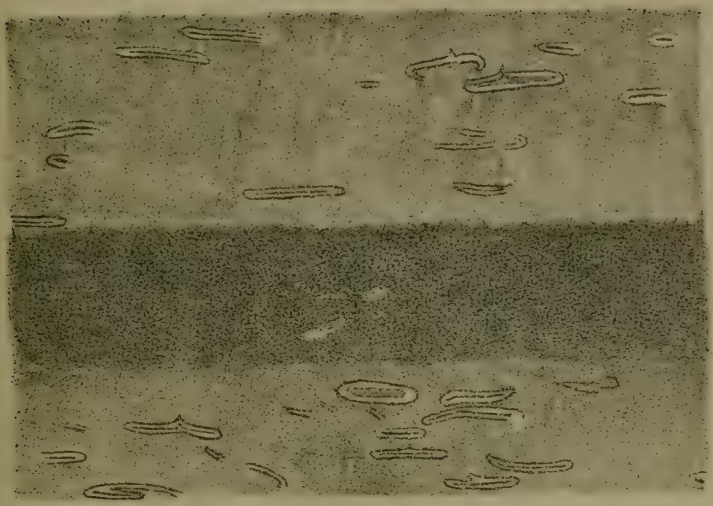
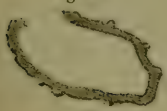


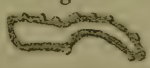
Fig. 21 ×12½

Fig. 22



×22

Fig. 23



×22

Fig. 24

×262

Fig. 25

×262

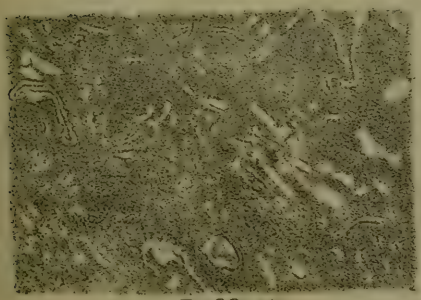


Fig. 26 ×12½

Fig. 30

×22

Fig. 27

×22

Fig. 28

×262

×262

Fig. 29

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PLATE 4

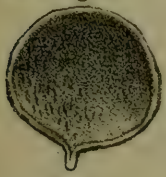
Fig 31

×22

Fig 33

×262

Fig 32



×262

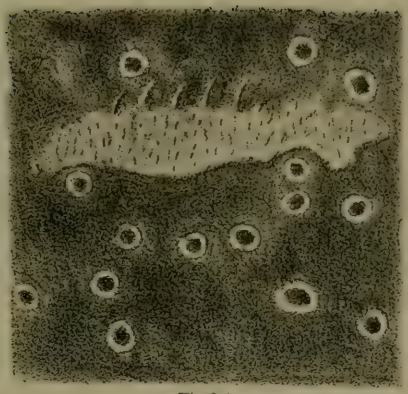


Fig 34 ×160

Fig 37

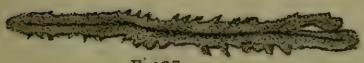
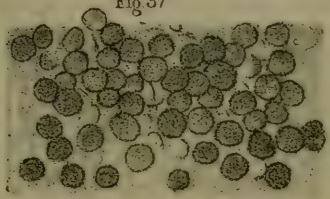
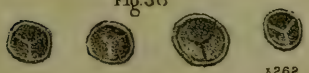


Fig 35 × 160



×160

Fig 36



×262

Fig 38

×160

Fig 39

×160

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Notes on the Breeding of Salmonidæ, read at a Meeting of the Cotteswold Club, March 31st, 1885. By Francis Day, F.L.S., and F.Z.S.

About this time last year I read a paper before this Society on "The Breeding of Fishes," since that period I have had the opportunity of continuing my observations on the interesting fish cultural experiments which are being carried on with such success at Howietoun, and a few months since it entered my head that even at Cheltenham I might endeavour to accomplish a little work in the same direction.

Although treatises on "Fish Culture" describe many excellent plans for hatching eggs of the *Salmonidæ*, I came to the conclusion that my time would not be wasted if I ascertained at how cheap a rate I could do so, and that in a manner suitable to the capacity of any gamekeeper or watcher, who might be in possession of a modicum of common sense.

In the course of my enquiries I extended my investigations into some debateable subjects, which I propose to briefly lay before this meeting, and which may be chiefly comprised under the following heads:—

(1.) Are the eggs of these fishes, when pertaining to the same species, invariably identical in size? or if they differ, on what does such depend? (2.) Do larger eggs produce superior offspring? (3.) Can salmon spawn in the sea? (4.) What is a par?

My apparatus* for egg hatching consisted of a paraffin cask, (well burnt inside) as a reservoir, having a tap fixed near its base, through which water passed into the water-supply tank, which latter had two taps fitted, one near either end and close to its base, so that each tap would be projecting over a hatching

* The cost was as follows:—One cask, well burnt out or charred inside 3s. 6d., tap 5s., supply tank and two hatching trays 15s., taps 4s. 6d., a second cask to keep a supply of water in 3s. 6d., a bucket 1s. 6d., as an egg extractor a leech glass 6d.; or an outlay of £1 13s. 6d.

tray. Each hatching tray near its lower end had a leaden overflow pipe, which projected over the tray next below it. A wooden cover fitted the top of each tray, with a hole to receive the water flowing down from above.

The cask, thirty-three inches high, was raised on empty boxes, and contained thirty-six gallons. The supply tank (inside) sixteen and a quarter inches long, six and a half inches deep, and seven inches wide. Each hatching tray (inside measure) eighteen inches long, six inches deep, and three and a half inches high, the water standing two inches deep, above this level the overflow pipe acting.

For the purpose of charring the inside of the casks they were filled with shavings, which were then set alight, the fear being not that the inside would be too much burnt, but more likely too little. As soon as sufficiently burnt the cask was inverted, to put out the fire, and when cold the inside was well scraped, and then washed out with water in which a little soda had been dissolved, and finally scrubbed with a birch broom. As any remains of paraffin would be deleterious to the young fish, it is best to let the cask stand full of water for some time before using it.

The insides of the supply tank and hatching trays were also burnt, while the outsides and covers were painted with Brunswick black. The water supply was from a contiguous pump, which doubtless, owing to having been mostly unused, soon got out of order, and gave a considerable amount of trouble, as I shall have to detail. The whole apparatus, raised on empty boxes, was placed in an unused coach-house, so also was the extra water cask from which the reservoir was replenished, in order that the newly added water might be of about the same temperature as that going to the hatching trays.

The water having been obtained from the pump in buckets, it was easy to calculate the amount used daily, because every bucket-full equalled the capacity of two hatching trays, or was equivalent to the water passing once through them, so twenty-four buckets-full in twenty-four hours was equal to the water going twenty-four times over the eggs. Although it is doubtless

true that these eggs may be hatched with the water being changed only once a day, that is not likely to produce vigorous fry. At Howietoun there is about one and a half inches of water flowing over the eggs, and which does so 160 times every twenty-four hours.

For the purpose of this experiment I was kindly supplied from Howietoun with about 500 eggs of the Loch Leven trout, averaging 0·21 inch each in diameter; they arrived on November 28th, about mid-day, having been spawned the previous morning from fish in pond No. 11. The eggs were in a cigar box, between layers of muslin in damp moss. The railway company had subjected the package to rather rough usage, the end having been broken while *en route*. The temperature of the inside of the box among the eggs was 50° F., and of the water in the hatching trays 45°. Nine of the eggs were removed as dead, and three the next day. Having to be absent from Cheltenham for five days, the eggs remained unpicked, the supply of water however being constantly renewed. On my return, on the 13th, the water from the pump had become so thick it could not be used, and some clean from elsewhere had to be obtained to wash the eggs, which was done with a watering pot. The eggs being deposited in the charred boxes, (which had only recently been prepared) had their surface covered with the remains of the charcoal or charred wood, as well as the mud from the pump water, which would evidently be much more probably fatal than when glass grilles are employed, for in these latter there is a space filled with water below the grilles, and although mud may be deposited on the top of the eggs, there is generally a clear space beneath, where it rests on the interspace between two glass rods. Irrespective of this, eggs deposited in flat trays are more subject to motion from the current of water than they are when laid down in trays in which glass grilles are fixed.

I do not propose detailing from my daily diary the various little mishaps which had to be detected and remedied, but some may well be noted, as these remarks are intended mostly for those who have never practically attended to fish-hatching.

On December 26th the eggs required another good washing, and the leech glass, used as an egg extractor, sucked up two good eggs at one time, and with such force that they became jammed together at its orifice, and had to be pushed out with a feather. Anticipating that this might possibly injure the embryo, they were placed by themselves, but eventually hatched out satisfactorily. January 26th, the water from the pump was coming up very clouded, and on the 28th the eggs had again to be washed. On the 31st the pump finally struck work, the sucker being choked with sand, so I determined to have the well cleared out. On February 4th had to move the entire apparatus, as it stood in the way of digging down to the well, the cleansing of which was completed during the day, and on the 5th everything was reinstated as before. Feb. 6th, had again to wash the eggs. On the 15th some of the ova had become of the clear-muddy colour, seen shortly prior to hatching. On the 16th two came out, and eleven more the next day. On the 20th only one more egg hatched, and on the 21st, on looking closely at the trays, most of the young fish were dead; some deleterious effects might have been due to a fall in the temperature, which commenced on the 19th, but it seemed to me to be more probably caused by some paraffin from one of the tubs having poisoned the young fish. For when the pump gave out an extra tub had been procured for spring water and allowing the sand to settle, consequently as only one tub full was used every twenty-four hours, the water remained forty-eight hours in each settling tub before being used. It seemed to me as if the water smelt slightly of paraffin, so every drop was got rid of, and the reservoir and trays filled up with fresh from the pump, which, if dirty, was not chemically deleterious.

On the morning of February 22nd, or the eighty-sixth day after the eggs had been taken from the fish, I found the great majority had hatched, and the question suggested itself whether hatching can be retarded should the condition of the water they are in be unfavourable? is it possible that the embryo have now burst their shells consequent upon the

fluid they are in being now suitable for their existence? But another cause may have been the real one, viz., that the temperature had risen from 3° to 6° during the preceding twenty-four hours, and it is well known that warmth as much hastens hatching as cold retards it. A few still continued hatching daily, fifteen on the eighty-seventh day, five on the eighty-eighth, two on the eighty-ninth, twenty-nine on the ninetieth, and fourteen on the ninety-first day. The eyes of the embryo were first very distinctly visible with a magnifying glass on the fiftieth day, but had been so for some time under the microscope.

The appearances presented by young trout when just hatching have been frequently described, consequently only call for a few remarks. Some embryos are stronger than others, and sometimes while looking at an egg it splits; first the head of the fish emerges, and a good plunge or two causes the shell to open along the back, or should the embryo not be very strong, it may be choked with its head emerging from the shell. Or one may be seen with its head entirely enveloped in the shell, but the rest of its body free, then with a dart it passes to another portion of the tray leaving the shell *en route*, at other times requiring more exertions for this purpose. In one case the yelk sac protruded first, and the young was a long time hatching.

A number of young fish huddled together, as they commonly are in one corner of the hatching tray, occasion a constant current with their pectoral fins, which is clearly beneficial, not merely as preventing dirt attaching itself to their gills, but also in driving away their now vacated shells. Having closely watched these fish when hatched, I do not find the gills this year partly uncovered by the opercles, as I have often seen in former years.* Short gill covers may permit irritation of gills

* Respecting young char DAVY observes, "when first hatched the branchial arches are naked, that is, fully exposed to view, the gill-covers as yet not being sufficiently developed to hide them. As in the instance of *Salmonidæ* and of other osseous fishes, no branchial filaments are known to exist in the fœtus. May not this place be supplied by this naked state of the branchiæ?"—*Phil. Researches*, p. 241.

and occasion gill fever, or some think gill fever may cause shortening of the gill covers.

On being hatched the appearances presented are peculiar. A large ovoid sac, the yelk sac, equal in length to about half that of the fish, passes from below the throat backwards and downwards, its posterior end sometimes being rounded, but in some instances ending in a sort of nipple-shaped point. Over its surface ramify numerous blood vessels, and the large umbilical vein conveys blood from it to the heart. Numerous oil cells are visible through its thin walls, also the liver and the vessels which supply it. Although the formation of the fins is foreshadowed, distinct rays are not visible. The various blood vessels, the pulsation of the heart, and the appearance of contractions in the caudal sinus are very distinct. The entire length of these little fish averaged about half of an inch.

On March 13th I found, different from what I had observed for the last few days, that the pectoral fins were no longer in constant motion, so I concluded that their necessity for thus assisting respiration had normally ceased. So I took one of these fish, now measuring 0·85 inch in length, and at 11.7 a.m. placed it in a tumbler of still water inside a room, the water as removed from the hatching tray being 42°. which rose in the room to 45° at 11.20. The fish had only been seven minutes when the pectoral began to be worked at the rate of three times to every movement of the gill covers, but as the little fish evidently became distressed, it was returned to the hatching tray, when its pectoral movements gradually ceased.

Among the hatched fish I have only observed one monstrosity, it having two heads, while after the hatching was completed only twelve bad eggs remained.

March 20th, the little fish in the trays seem not altogether comfortable, a few having died, so I turned in a heap of fine sand in each, which appeared to give great satisfaction.*

December 23rd, three of the eggs having been placed in a half cell containing water under the miscroscope, and in a

* Up to May 26th, no further deaths occurred. The double headed one died May 25th.

strong light, gave the following appearances:—In one and a half hours an opaque spot showed itself in each, which rapidly spread and death ensued, caused possibly by light, by a raised temperature, or deficiency of respiration. On December 23rd placed three eggs in a hatching tray, on a white earthenware palette, putting one into each partition, one and a half inches of water flowing over them. The cover of the tray was left off, and the coach-house door put open, so as to give a good amount of light to the ova. Three more eggs were put into the dark part of the tray for comparison, and which hatched in due time. On February 23rd, observing that most of the eggs in the trays had hatched, but that the three on the palette were still in the ova state, I tried, as an experiment, a plan I had been informed of at Howietoun of transferring eggs near the hatching period from glass or metal substances to wood, which usually expedites hatching. I placed them in the tray at 10 a.m., and in about two hours one had assumed the peculiar colour showing that it would soon hatch, and by one o'clock it came out; a second hatched at five p.m., and a third during the night. I have reasons however for believing that light is injurious to the eggs of the *Salmonidæ* during the incubating stage.

January 8th, 9.30 a.m., two trout eggs were put into a tumbler of salt water, of the specific gravity of 1019°. This water had been received from Weston-super-Mare, through the kind offices of Mr Wethered, but, owing to the journey, was rather turbid. The water in the tumblers was three inches above the eggs, and changed every morning. 9th, 2 p.m., eggs look as if dead, but took them over to Mr Wethered's, to put under the microscope, as my glass case had been broken. One was found to be dead, (the eyes being prominent and the mouth open) the other to be alive. As the condition of the water may have acted deleteriously, determined to try this experiment over again.

January 9th, 2 p.m., placed two more trout eggs into a tumbler of salt water, which was now clear, the tumbler in this and the other experiments being placed in a hatching tray, so

that the water stood about half way up its sides. 10th, 3 p.m., one egg looks a little cloudy, but the other is clear. 11th, 9 p.m., one certainly dead, but a little vitality in the other: 2.30 p.m., both dead, or 48 hours from the commencement of the experiment.

January 9th, 2 p.m., placed two eggs, under exactly similar conditions, in a tumbler of brackish water, of 1008° specific gravity. 21st, eggs have been going on pretty satisfactorily, so changed the water to 1019°, and so continued it for two days, and then reverted to 1008°. Feb. 24th, 10 a.m., as they had not hatched, they were put into a tumbler of fresh water, and brought in-doors, when the temperature of the water rose from 48° to 60°: at 1 p.m., one of the eggs began to look as if it would probably hatch, and at 4 p.m., the young came out. I now removed it to another tumbler, and gradually cooled the water down, and returned the fish to the tray, where it did well. March 1st, 10 a.m., the other egg commenced to hatch, the yelk-sac coming first; at 5 p.m., it hatched, and was seen to have dropsy of the sac. This little fish was likewise returned to the tray, but did not do well; the movements of the heart were very languid, pulsations 84 per minute, and under a strong glass various congestions were seen in the course of the blood vessels as at the upper side of the orbit, but in most parts of the body it was very anæmic. The clear interspace between the yelk-sac and its outer covering was very distinct. It died on March 7th. As dropsy of the sac is usually considered a result of constitutional weakness, and no other example suffering from it, it is reasonable to conclude that such must have been the effect of the brackish water in which the egg was kept.

January 9th, 2 p.m., for the sake of comparison placed two trout eggs in a tumbler of fresh water, under the same conditions as the foregoing, changing the water daily. February 24th, eggs not having hatched, they were placed in one of the hatching trays, on the wooden floor of which they both came out in twelve hours' time.

January 21st, 10 a.m., placed two trout eggs in salt water, at 1019°; 25th, 4 p.m., both were dead, or within four and a half days.

January 23rd, 3.30 p.m., two more eggs were put in brackish water, at 1012°; 26th they appeared to be a little dull; 27th, placed in a cell under the microscope found to be alive, but languid. Feb. 24th, one appears to be dead, but not so the other; both placed in hatching trays, but with no alteration. Feb. 28th, both brought into house in tumbler of fresh water, which increased the temperature from 48° to 60°; one of the ova seemed inclined to hatch, but finally did not do so.

March 12th, 8.20 a.m., a fine frosty morning. Removed forty-two young trout and four young salmon in a live bait can, which I carried to the rail and went by the 8.40 train to Churchdown, arriving at 8.52 a.m. I then carried them to the Badgeworth stream, accompanied by Mr. Ellis Viner, hides having been constructed in some nice gravelly spots where the water did not exceed five or six inches in depth, and the stream was about three or four feet wide. The hides were made by placing two bricks pretty close together, parallel to each other, and to the course of the stream, while on the up stream end another brick was placed transversely to break the force of the current. This was covered by an eave-roof tile. They may do well, as the elvers do not abound until May, and although some crayfish were turned into the brook two years or more ago, all appear to have died. Possibly the bull-heads and sticklebacks may prove serious enemies.*

March 19th, took 364 young trout to Colesbourne, starting at 9.20 a.m. As the road is rather hilly and not over smooth, carried the fish in two bait cans, slung on strong sticks hanging across from one seat to the other of the pony carriage. On the surface placed some ice, while with an umbrella kept off the sun. At 11.30 a.m. turned 304 into two spring heads, and subsequently about thirty in the stream near the fish ponds, where there was a nice pond-like piece of backwater fenced off to prevent the access of large fish. About thirty more were placed in the large fountain, the water of which was run off, the place cleansed, and, having put some stones in for hides, the water

* April 14th, took about 100 more young trout and salmon to Badgeworth stream.

was turned on again to six inches in depth. If moorhens and "tommy culls" (*Cottus gobio*) do not destroy those in the stream, or frogs those in the fountain, these Loch Levens ought to be a good addition to the local race of trout. *

DATE	INDOORS		OUT OF DOORS AIR		EGGS		Water
	Water 9.30 a.m.	Air 9.30 a.m.	Maxim.	Minim.	Died	Hatched	No. of times daily through Trays
1884.							
Nov. 28	...	...	44°	40°	9	...	6
„ 29	...	...	38	30	3	...	4
„ 30	...	...	38	24	...	...	3
Dec. 1	...	...	38	32	...	...	3
„ 2	...	...	41	34	...	...	4
„ 3	...	...	...	50	...	...	2
„ 4	...	...	45	41	...	...	3
„ 5	...	...	52	39	...	...	...
„ 6	...	...	52	42	...	...	4
„ 7	...	...	53	47	...	...	3
„ 8	...	...	53	45	2	...	8
„ 9	...	...	45	40	3	...	5
„ 10	...	...	50	35½	2	...	6
„ 11	...	...	50	45	...	..	5
„ 12	...	...	51½	43½	2	...	6
„ 13	...	...	54	45½	...	...	4
„ 14	...	...	53	49½	8	...	7
„ 15	...	...	53	41	2	...	4
„ 16	...	...	53	33½	...	...	5
„ 17	...	...	41½	33½	...	...	6
„ 18	...	...	50	32	...	...	6
„ 19	...	...	46	37	...	...	4
„ 20	...	...	42	36	...	...	5
„ 21	...	...	38	33½	...	...	7
„ 22	...	...	39	33½	...	...	6
„ 23	...	...	38	34½	1	...	5
„ 24	...	...	36	34	...	...	4
„ 25	...	...	37	31½	...	...	5
„ 26	...	...	36	32½	8	...	10
„ 27	...	...	35	31	1	...	7
„ 28	...	...	35	33	...	...	8
„ 29	...	...	35	33	1	...	10
„ 30	...	...	34	32	1	...	8
„ 31	...	...	...	28	5	...	6
1885.							
Jan. 1	...	...	34½	31	...	...	8
„ 2	...	...	34	29	1	...	5
„ 3	...	...	35½	29	...	...	13
„ 4	...	...	41	33	...	...	5
„ 5	...	...	50½	37	...	...	7
„ 6	...	...	41½	25½	...	...	10

* April 28th, turned 22 young trout into the Chelt. May 15th, turned 6 young trout into the stream above the Pittville Lake.

DATE	INDOORS		OUT OF DOORS AIR		EGGS		Water
	Water 9.30 a.m.	Air 9.30 a.m.	Maxim.	Minim.	Died	Hatched	No. of times daily through Trays
1885.							
Jan. 7	...	...	43	26	4	...	19
„ 8	...	...	43	35	...	...	8
„ 9	...	...	48	31	1	...	10
„ 10	...	...	49½	34	...	...	8
„ 11	...	...	43½	39½	...	...	4
„ 12	...	...	37½	31½	...	...	4
„ 13	...	...	34	29½	2	...	10
„ 14	...	...	33	28	1	...	10
„ 15	...	...	36½	30½	1	...	8
„ 16	...	...	38	34	...	...	10
„ 17	...	...	36	34	...	...	9
„ 18	...	...	36½	33½	...	...	9
„ 19	...	...	35	34	...	...	10
„ 20	..	...	31½	31	...	...	7
„ 21	34°	34°	32°	28°	...	...	8
„ 22	33	33	36	26	3	...	8
„ 23	35	35	35½	31	1	...	22
„ 24	36	36	35	32	...	...	9
„ 25	36	36	37	32	1	...	22
„ 26	39	41	46	32½	...	...	22
„ 27	45	46	47	43	...	...	17
„ 28	45	47	53	46½	9	...	17
„ 29	47	51	52	49	...	...	8
„ 30	48	49	57½	48	...	...	22
„ 31	46	46	...	40	1	...	10
Feb. 1	44	44	51	41	...	...	10
„ 2	44	44	52	41½	...	...	22
„ 3	45	45	46	42	...	...	6
„ 4	45	45	44	34	...	...	14
„ 5	45	45	45½	34½	...	...	22
„ 6	41	41	48	38	3	...	23
„ 7	45	45	49	41½	...	...	22
„ 8	48	48	51	42½	...	...	9
„ 9	41	41	41½	37	...	...	22
„ 10	44	42	48½	35	...	...	14
„ 11	44	46	54½	40	...	...	13
„ 12	47	49	52½	46½	1	...	12
„ 13	47	47	49	45½	...	...	12
„ 14	48	48	53½	46	...	...	13
„ 15	47	47	54	43½	...	...	13
„ 16	47	47	43	40½	...	2	16
„ 17	43	41	41½	35	...	11	21
„ 18	40	40	44	29	...	...	21
„ 19	38	38	43	27½	...	...	19
„ 20	38	36	38½	31½	...	1	18
„ 21	36	34	45	32½	1	...	21
„ 22	40	43	53	34	1	hundreds	21
„ 23	42	43	51½	39	...	15	21
„ 24	46	47	59	44½	3	5	20
„ 25	48	48	54½	46	...	2	22
„ 26	47	47	...	42½	...	...	22
„ 27	48	50	58	47	...	29	18
„ 28	48	49	...	46	...	14	19

January 17th, received from Howietoun a box containing 45-eyed salmon ova, varying in size from 0·20 to 0·25 of an inch in diameter, the large ones having been taken November 19th from a 16lb Teith fish, and the small eggs from one of inferior size from the same river. About four were dead on arrival.

February 8th, three of the eggs out of twenty-three were found to have hatched. As these were taken on November 19th they were eighty-one days up to the period of hatching, and on being hatched they were half an inch long. On the 16th two eggs hatched, and they were all out by the 21st except one. Most came forth head first, the shell splitting down the back.

On February 21st one of the fish was completely out of the shell except its head. It had attempted to enter the world tail first, and was now like a cat with its head in a stocking. Several ineffectual attempts were made to release it by means of brushes, and so on the 27th, feeling satisfied that unless freed it would die, took a sharp pair of scissors and succeeded in inserting one end and then dividing the shell. As the fish constantly wriggled about care had to be taken not to cut it. This fish subsequently did well. There were no monstrosities among these fish.

January 19th, 1 p.m., placed three eggs in a tumbler of salt water, of the specific gravity of 1,021°. On the second day they became slightly cloudy, and they were found to be all dead after three days' time. The water having been changed daily, similarly to the experiment on trout eggs, as well as in the following ones.

January 22nd, 10 a.m., repeated the foregoing experiment. All were dead at the end of three days.

January 19th, 10 a.m., placed three eggs in a tumbler of salt water at 1,012°. They were all dead in three days and five hours.

January 28th, 11.30 a.m., placed two eggs in a tumbler of salt water at 1,012°. Next day a little cloudy. Died on the eighth day.

January 28th, 11.30 a.m., placed two eggs in a tumbler of brackish water at 1,007°. The water seemed dirty, and on February 1st they were dead.

February 2nd repeated the experiment. One hatched in seven days and two hours, and on the 9th, having to leave Cheltenham, the remaining one was transferred to spirit, and the embryo was found to be alive.

January 18th, placed three eggs in a tumbler of fresh water, changed daily. On the 26th all the others similarly treated with salt water being dead, these were returned to the trays and hatched in due time.

January 28th, 11.30 a.m., placed two eggs in a tumbler of fresh water, and on February 7th, as they had not hatched, transferred them to the wooden tray, and they subsequently hatched.

SIZE OF EGGS OF SALMONIDÆ.

We will now pass on to the eggs of Salmonidæ, premising that size is no criterion as to locality where ova are deposited. The *Siluroid Arünæ* deposit their eggs, which are very large, in the salt water along the sea coasts. Those of the *Arius* are as large as any of the family, whereas the closely allied *Bagrus*, which deposits it in fresh water, have them very small. The carp genus *Barilius* in some species, at least, has large eggs, which is not the general rule in the carp family.

If, however, we restrict ourselves to the eggs of the salmon, trout, and char, there is an excellent field for observation, respecting whether the size is in comparison with that of the mother; if it is dependant on her age; whether local circumstances affect it; and lastly, whether such have any influence on the future offspring. Many have written on this question, but not a few have simply copied the remarks of others, and thus erroneous opinions have been more prevalent than such as are simply exponents of well-ascertained facts. When this phenomenon is examined, it offers at least three distinct points for investigation. 1. Are the eggs of the *Salmonidæ* of one species invariably of the same size, or do they differ in accordance with the age of the parent? 2. Is there any difference in the size of the eggs in two parents which are of the same age? 3. Can we detect any variation in the size of the eggs from a single parent?

I think I can produce conclusive evidence that a widely-received opinion of the eggs of each species being of identical size, no matter what the age or size of the parent may be, is founded on error and not the result of observation.

In the year 1767, HARMER wrote in the "Transactions of the Royal Society," an exceedingly interesting paper on the "Fecundity of Fishes." He remarked, "from this table it appears that the size of the eggs is nearly the same in great and small fishes of the same species at the same time of the year." Passing over the remarks of numerous naturalists in this country, some being their own observations, and others merely copies of those of their predecessors, we may well commence extracts about 1864, when the "Zoological Record" was began. Professor MALMGREN having ventured to assert that certain *Salmonoids* in a Finland lake were descendants of the common salmon, whose access to the sea had been cut off owing to the elevation of the land, mentioned as one of the differences that this dwarfed breed had smaller ova than seen in the *Salmo salar*. Criticising this opinion of Professor MALMGREN, Dr GÜNTHER observed that "the last character," or size of the ova, "will be considered very significant by all who may have a more extended knowledge of fishes, as the size of the ova is not only invariably the same in individuals of whatever size, but, as far as our experience reaches, is even often characteristic of the species of a genus."

BLANCHARD (Poissons des Eaux Donces de la France, 1866, page 461) observed that "the eggs of the grilse are always sensibly smaller than those of the adult salmon."

LIVINGSTON STONE, "Domesticated Trout," third edition, 1877, remarked that in American trout, *Salmo fontinalis*, which reside in spring water, which is equivalent to a diminished supply of food, smaller eggs are developed than in such as reside in brooks. In the report of the United States Fish Commission on the McCloud river, California, "it was noted in 1878 that the parent salmon were unusually small, their average weight being under 8lb." This small size was stated "to be undoubtedly caused in whole or in part by the fishery at the canneries of the Sacramento, where the 8-inch meshes

of the innumerable drift nets stopped all the large salmon, but let all the small ones through. The eggs when taken proved to be at least one-third smaller than those of most previous years, and the average number of eggs to the fish was about 3,500, against 4,200 in the previous year."

Subsequently (1880) Dr GÜNTHER observed, in the "Introduction to the Study of Fishes," that "the ova of teleostean fishes are extremely variable in size, quite independently of the size of the parent species. The ova of large and small individuals of the same species, of course, do not differ in size." (Page 159). LIVINGSTON STONE, in the "Bulletin of the United States Fish Commission," 1882, vol. ii., page 11, observed, respecting the eggs of the *Salmo fontinalis*, that those taken from the larger breeds are fully twice the size of those given by such as reside in mountain rivulets. From this period several observers have noticed that the eggs of *Salmonoids* undoubtedly differ in size consequent on certain physical causes, consequently the author who would characterise a species by the size of the eggs, would possibly be merely adding another synonym to the confusion previously existing. A certain excuse may be offered that prior to the formation of the Howietoun fishery either very little or no pains had been taken to segregate the fish of different ages, consequently means were not available for solving the question. I now propose to give the size of the eggs of these fishes as observed during November this year, premising that besides measuring individual eggs, care was taken to measure six, eight, or ten in a row, and take the mean as the average size.

Salmon eggs were from 0·20 to 0·30 of an inch in diameter; from smolts or grilse raised in the Howietoun ponds, from 0·20 to 0·22 inch; from a small sea trout, 0·175 to 0·18 inch. *Loch Leven* trout, at eight years old, 0·20 to 0·24 inch; at seven years old, 0·19 inch; at six years old, 0·185 to 0·19 inch; at two or three years old, 0·17 inch; thus clearly showing that the average diameter of trout eggs increases with the age of the parent at least up to the eighth year. The American char, *S. fontinalis*, at two year old, 0·13 to 0·14 inch; at three year

old, 0·17 inch; at four years old, 0·18 inch. A *hybrid char* being a cross between the British and American forms, the diameter of the eggs, at nearly two years of age, was 0.13 of an inch.

DO LARGER EGGS PRODUCE SUPERIOR OFFSPRING?

The next question is whether there is any difference in the size of the eggs in two parents which are of the same age and kept under the same conditions? In two Loch Leven trout, each six year old, a difference did exist, the diameter of the eggs in one being 0·19 of an inch, and in the other 0·18 of an inch. And that such might occur would even theoretically appear highly probable; for, as I have remarked, LIVINGSTON STONE observed that where food existed to a minimum amount the eggs were small; in fact, a deficiency of nutrition may occasion diminution in the magnitude of the ova. Also the size of the parent ought possibly to be likewise taken into account, for disease, crowding them when young, or other causes, may dwarf fish, and such a one would doubtless furnish comparatively small eggs. Can we detect any variation in the size of the eggs from a single parent? In this I exclude abnormal or diseased eggs, and still find that a variation in size does occur among the eggs from one fish. Such in 1854 was pointed out by RANSON as observable among the eggs of the stickleback. I had eighty eggs of a Loch Leven trout spawned direct into a glass tube containing water, wherein they were kept for a week, the water being changed daily, and they became more distended than when first taken. Seventy-five were 0.25 of an inch in diameter, three were 0·20 of an inch, one was 0·175 of an inch, and one 0·15 of an inch. In looking through a large number of eggs of *Salmonidæ*, it seemed that from four to five per cent. are mostly smaller than the average size. Irrespective of the foregoing proving that the size of the eggs varies with the age and condition of the parent in the Loch Leven trout, I should mention that along with augmented sizes of the ovum is an increased thickness of the shell, a rather important subject for the fish culturist,

because such shells require a strong embryo in order to hatch, which is obtained by augmenting the water supply during the eyed period.

Eggs of *Salmonidæ* differ not only with the age of the fish, but from various causes, and it is now necessary to show why I believe that the offspring from large eggs are superior to such as are reared from small ones, and why fish culturists should be careful to obtain their stock from the best sources, unless the water in which they are going to be placed is deficient in amount or in food when the source from whence the breed is obtained is of very little, if any, consequence. Two batches of Loch Leven trout were spawned on November 2, 1882, at Howietoun, the parents of one lot having been hatched in 1875, and of the other in 1876; the eggs were similarly treated, and the young came out during January and February, 1883. At Craigend are two ponds, which have been constructed for the reception of young fish, each 100ft. long and of the same width; one is nearly on a level with the other, and the identical stream passes through both. Into these two ponds the two lots of fry were turned, those from the older parents (1875), or seven-year-old parents, having the lower pond; those from the younger or six-year-old fish having the upper pond, while they were fed and otherwise similarly treated. At the end of November, 1883, those in the lower pond were about one-fourth larger than those in the upper pond, and it seemed as if the produce of the older parents or larger eggs were decidedly superior to those from the younger parents, or smaller eggs.

In 1884 a second experiment was tried in the same two ponds, which were stocked with young Loch Leven trout, bred from parents of the same age, spawned the same day and hatched in the same room. I saw these fish both in August and also in November, but no difference in size or appearance was perceptible between them. It would, consequently, seem that the larger eggs produced from older parents produce fry which grow faster than do those from the smaller eggs furnished by younger parents.

In the evidence taken before the Salmon Commission of 1824, Mr Little observed that "the Shannon fish are very

large, few of them under 20lb., and many of them 30lb. and 40lb. and upwards. The salmon that are bred in the Bush never get larger than 9lb. or 10lb. A large salmon never will come from a small breed. A Bush salmon could never grow to the size of a Shannon fish, though he were to live to any age."

These are subjects that I believe are worthy the attention of fish culturists and naturalists, and replies to which can only be given by an attentive consideration of the fish in their breeding and rearing grounds. Of course, without perfect segregation, as is now carried on at Howietoun, observations will not be of any material value. It is the field, and not the museum naturalist who must be expected to solve these points, and, if the propositions I have made are correct, it would be worth while for an investigation to be properly carried out into whether the same phenomena occurs in other families of fishes, or even in other orders of animal life. Will, in short, the spat of a small oyster produce an equally fine race to that from larger and better fed molluscs?

CAN SALMON SPAWN IN THE SEA?

Although my main object in undertaking a small trout and salmon hatchery at Cheltenham was to ascertain the expense such would really entail, and the trouble which would be required in bringing such to a satisfactory conclusion, I was also, as I have observed, desirous in a small way of trying a few experiments which might be practically useful, or solve any unsolved question. One of these is, *Can salmon spawn in the sea?* I do not propose entering into the history of all who have written for or against this theory or conjecture, but if we turn to Gesner (A.D. 1598) we find he remarks that the salmon was quite unknown to the Greeks. It is a fish belonging to Germany and the inhabitants of the coasts of the German Ocean, for from the sea only do such fishes come. Its form is well known to the Germans, for which reason but little will be said concerning it. It is only necessary to observe that they change their name according to the time of the year, or their age; that in the spring and through the summer, until St. James's Day, they are called *Salm;* after that they receive the

name of *Lachs*, at which period also they have a curved knob at the end of the lower jaw, and are beautifully spotted. The crook on the lower jaw is much larger in the male than in the female. They are only found in rivers which empty themselves into the German Ocean. Sometimes they are of great size, even reaching 36lb. The shoulders are fleshy. Internally, they are formed so that one sees two openings from the mouth down the throat, the one into the stomach, the other, which is closed by a thin white skin, not proceeding far. These fish may be regarded according to the way that they ruminate or chew their food, after the manner of some four-footed animals. They have many teeth upon the tongue, which is short and broad.

The Nature and Properties of the Salmon.—Those who have written on the properties of the salmon are not unanimous. Some write that the salmon spawns only in the sea, then comes to fresh waters to grow. Others, again, say that as the salmon grow up from the eggs, towards winter in the fresh water, in which they grow a little, subsequently returning to the sea, where they become full grown, and afterwards they ascend the fresh water streams, which opinion is not only that of experienced fishermen, but is confirmed by our daily experience, for salmon are largely caught by us. After Christmas Day, that is, at the end of the 12th month, they are no more seen. There are two reasons advanced for the salmon doing this; first, that they spawn and spend their youth, and grow large in the sea; the second is, that they return to the river and spawn when of suitable size.

Pontoppidan (Natural History of Norway, 1755) asserted that he was well assured that salmon chiefly eject their roe at the mouths of rivers, where they empty themselves into the sea, or else a little above the salt water.

If this last opinion were correct a question might arise whether there is any necessity for protecting salmon rivers, as did they spawn in the sea many of their young could be raised in the same localities.

It is useless pointing out to the advocates of this opinion, who are mostly net fishermen, that could they do so, why do

they push up into rivers for breeding purposes, and that as far as they can ascend from salt-water influences? They do not select a spot between high and low-water mark along our inlets and bays, for there their nests would be liable to be disturbed by the ebb and flow of the tides, whereas if they selected the deeper portions of the ocean it does not seem clear how the eggs would be sufficiently ærated.

It is true that if we refer to the Report of the Committee of the House of Commons on Salmon Fisheries (1824-25) we find them asking a witness, Mr Johnstone—"Is the committee to understand that there are salmon which frequent the friths, and go out to sea again without going up the rivers?" To this he replied, "Yes," and he also remarked that although they generally spawn above the influence of the tides they may spawn where the tide reaches. And they subsequently interrogated Mr Halliday thus—"Are there a great many salmon which come into the friths that do not go to the rivers but return again to the sea?"—"There are a great many." While Mr Steavenson, of Fortrose, deposed "that there cannot be a doubt that salmon spawn in the sea."

During the winter of 1824 Mr Hogarth found that salmon ova taken from the river Don and put into salt water, never came to life, from which he inferred that if salmon spawn were deposited in the sea it would not be evolved.* Sir Humphrey Davy observed of the salmon: "Sometimes, indeed, in very small streams it deposits its spawn almost close to the sea in gravel, where the stream meets the waves at high-water mark (l.c., p. 144).

Sir James Matheson† has recorded a similar instance at the mouth of the Greamster in the Island of Lewis, continuing that the spot is covered with "brackish water" only for about two hours at each high tide, but not at all during the neaps, while this brackish water is so diluted as to differ but little from fresh water in specific gravity, the tide serving as a dam to the river water, and, by obstructing its free outflow, causing its accumulation and overflow.

* Parliamentary Committee on Salmon Fisheries, 1824, page 62.

† Davy, Physiological Researches, page 261.

Doubtless, salmon and sea trout will spawn in salt water at times, but should an investigation be instituted such is generally found to be consequent upon a want of sufficient water in the rivers to enable them to ascend to their spawning beds, while they cannot retain their ova for an indefinite period. Mr Jackson* recorded that "the salmon-trout cast their ova in the salt water at the Southport Aquarium, without assuming the appearance of kelts, or even leaving off feeding greedily on shrimps. They did not attempt to make a bed, and the spawn was immediately eaten by their fellows." It would seem in this case that the fish, aware of the uselessness of forming a redd, did not take the trouble to do so.

About 1862 Mr Sinclair made some experiments in Ireland on the effects of salt water on salmon ova, remarking† upon having taken about one hundred eyed salmon ova, of which two portions were enclosed in wicker baskets and buried in separate streams, one of which was reached every tide by salt water, whereas the other was entirely fresh. They were examined in about three weeks after one set of spring tides, when all which had been reached by salt water were found to be dead; not so those in which the stream was entirely fresh water. The remaining third were hatched in a wash-hand basin, in which was fresh water changed once a day. He subsequently observed ‡ that since then he had two or three times seen salmon redds in the same tidal water, and had been assured by his head water bailiff that he had seen one a quarter of a mile lower down, where the gravel was covered over by neap tides; also, he had been told that in another river, on a particular ford which is affected by spring tides, but only in a slight degree, half-a-dozen redds are generally to be found every winter.

Mr J. Jackson, § writing of the Yorkshire Esk, recorded, respecting salmon ova, that "it is an interesting question,

* Land and Water, June 10th, 1876.
† "Field," Feb. 4th, 1882.
‡ "Field," March 7th, 1885.
§ "Field," Dec. 20th, 1884.

however, as to what amount of brackish water will destroy it; and, as we have a lot of spawning fish depositing their ova in the stream, just below Ruswark Mill dam, over which they cannot get when heavy in spawn, and up to which spring tides rise about two or three feet, covering the spawn beds for about two hours each tide for some three or four days at each period of high tides. Some ova from fish spawning there was procured and placed in a box in the gravel at that spot. This was done in order to ascertain whether it would come to life. Though nothing came of the experiment for the first two years, it was found that this year a good portion of it was hatched, thus showing that it was not all killed by salt water. Another account states that some of the ova were removed from this box, and hatched in a basin of fresh water in the village brook, whereas all that were left in the box died.

Sir J. Matheson, during the winter of 1861-62, had two portions of impregnated salmon eggs used, one for trial in brackish water of specific gravity 1,015, the other in fresh. They were held on a wire cloth in a glass vase with a tap at its bottom, and the water was changed daily. During the first ten days the ova in the brackish water did not appear to suffer, and no longer; no fœtal development was observed in them, and they all died, while those in the fresh water made progress, and in due time were hatched.

Dr. Davy tried the effects of a solution of common salt in water, having a specific gravity of 1·026° on a salmon egg, the embryo in which appears to have succumbed in a few hours over two days. The ovum of a Dee salmon in similar water, of a specific gravity of 1·007° was hatched at the end of about forty-eight hours; the young was very languid, but at the end of the fourth day was still alive.

Brown, in his account of the Stormontfield experiments, observed:—"We have also taken ova which had been recently manipulated upon, and dropped it into sea water, which destroyed it almost instantaneously, only a few of them becoming opaque; in the greater portion of them the yolk became shrivelled up and contracted."

Mr Brander, in *The Field*, remarked upon having observed during the preceding summer some holes scooped out in the gravel close to the mouth of the small river Lossie (near the Spey) and within the reach of the salt water, and here he found in January, 1882, a few salmon working at their redds, which were within a mile and a half of the sea, and covered once a fortnight, at spring tides, with quite salt and undrinkable water for perhaps an hour's time.

Several correspondents to *The Field* and elsewhere appear to be sanguine that in time they will hatch salmon in such localities; and in fact, it has been asserted that they must have done so in the Yorkshire Esk.

Under the conflicting accounts representing sea water as certain death in all instances wherein the experiments had been brought to a conclusion, and only conjecture being the ground for a belief that *Salmonoid* eggs would hatch in such a situation, I thought it well worth endeavouring to come to a decision on the point. My experiments were certainly primitive ones, and it may be objected that the ova being in tumblers and the water being only changed once daily, placed them under unnatural conditions, but the eggs similarly placed in tumblers of fresh water hatched. Also two trout eggs kept in brackish water at the specific gravity of 1008° (except for two days at 1019°) from January 9th hatched February 28th and March 1st, but one had dropsy of the sac, apparently due to the medium in which they had been kept. It would be better if in future experiments the water be kept flowing.

WHAT IS A PAR?

The young of the salmon in Acts of Parliament were formerly designated as fry and smolts, while of late years the term par has been commonly used, and which has been said to be calculated to mislead, because there are salmon par and trout par. This brings us therefore to the consideration of what is a par? And I think a short history of the controversy this question has raised will be interesting, for in such Zoologists, fishermen, learned divines, doctors, lawyers, poachers, in

fact almost every class has joined. Arguments for and against their being the young of the salmon have been employed, invectives against opponents have been freely indulged in, and all because no one would hatch the little fish from the ovum, and ascertain the various changes it went through in the course of the first few years of its life.

As this history is a most instructive one I propose giving a short summary of it, as well as exhibiting the fish as it has been reared direct from the egg of the salmon, also as it is turning into a smolt, and after it has become a grilse.

Isaak Walton *Compleat Angler*, 1653, remarks that "in divers rivers, especially that relate to or be near to the sea, as *Winchester* or the *Thames* about Windsor, is a little trout called a 'samlet' or 'skegger trout,' and that these be by some taken to be young salmons,"

We find Willoughby (*Historia Piscium*, 1686, page 192) giving a description of the *Salmulus* or "samlet" of Herefordshire, which, he tells us, inhabits the Wye, and all which he has examined were males; he however places it as a distinct species. In the next page he gives it as *branlins* or *fingerins*, and asserts that he is persuaded that they interbreed with the salmon, and are only found in such places as are frequented by the salmon. Willoughby was persuaded that all the various species of the genus *Salmo* interbred.

Ray (*Synopsis Methodica Piscium*, 1713, page 63) classes the samlet of Herefordshire and the branlin and fingerin of Yorkshire all as one species, and of which it is affirmed all are males.

Captain Francks (*Northern Memoirs*, 1658, page 301) describes "the various brood of salmon, so to distinguish them according to mode, or as some will have it the custom of the country. In the south they call him 'samlet,' but if you step to the west he is better known there by the name of 'skeggar;' when in the east they avow him 'penk;' but to the northward 'brood' and 'locksper,' so from thence to a 'tecon,' then to a 'salmon.'"

J. Williamson (*The British Angler*, 1711, page 138) considers "the 'samlet,' or 'salmon-smelt,' or, as they are called by some, 'salmon-fry,' are only so many different names for the 'young salmon.'"

Pennant (*British Zoology*, iv., 1776, page 303) says the samlet is the least of the trout kind, it is by several imagined to be the fry of the salmon, but from which he dissented, first, because salmon fry vanish on the first vernal flood after they have been born, and which sweeps them into the sea, leaving scarce one behind; and secondly, because the growth of the salmon fry is so quick and so considerable as suddenly to exceed the size of the largest samlet. That the salmon attains to a considerable size before it breeds, while samlets on the contrary are found male and female, although it has been vulgarly imagined that there were no other than males of this species. That they are present all the year round in the rivers, and spawn in November and December. He concludes "these fish are very frequent in the rivers of Scotland, where they are called 'pars;' they are also common in the Wye, where they are known by the name of 'skirlings' and 'lasprings.'" He gives a short extract from Mr Potts respecting the salmon of the Tweed,—"about the latter end of March the spawn begins to exclude the young, which gradually increase to the length of four or five inches, and are then termed 'smelts' or 'smouts.' About the beginning of May the river is full of them, it seems to be all alive; there is no having an idea of the numbers without seeing them; but a seasonable flood then hurries them all to the sea, scarce any or very few being left in the river."

Turton (*British Fauna*, 1807 page 104) admits *Salmo salmulus* as a distinct species.

Should we now turn to the "Reports on the Salmon Fisheries of the United Kingdom," drawn up by a Select Committee of the House of Commons, in 1824 and 1825, one finds a considerable amount of evidence as to what par were considered in those days. One witness (G. Little. page 113,) on being asked if he had ever known them found in any river where there were no salmon? replied, "I do not know that I have, I never took particular notice as to them, but I consider them a fresh water fish, unconnected with our salmon fisheries altogether." But on being asked at what season of the year does the salmon fry begin to go down to the sea? he at once

answered that "when the natural warmth comes into the water in the month of March, the fry generally rise, and they continue going down from that time until the 1st May; sometimes I have seen them going down till the month of June," (page 115.)

Mr Hogarth, in May, 1824, when samlets were descending the Don, had a number of them captured and marked, by cutting off the *mort* or dead fin. During the month of July several grilses were taken without that fin, whence he inferred that they were some of the fishes which he had previously marked. Not only did samlets thus become grilses in a few weeks, but in the following year, 1825, he got three salmon, marked in the same way, which he also considered to be some of those individuals he had marked originally as samlets. In September, 1824, he caught ten or twelve grilses, which were put into a salt water pond. Owing to high tides some escaped. but there were three alive the following May; these were taken out and examined in the presence of many competent judges, who were all decidedly of the opinion that they were real salmon. These experiments showed not only the growth of the smolt or samlet into grilse or botcher, but also that of the grilse into the gilling or salmon of one year's growth.

One must however decline assenting to some of Mr Ellis's conclusions ("Natural History of the Salmon," in the *Edinburgh New Philosophical Journal*, 1828, page 250 et seq.) viz., that salmon "frequently propagate their kind during the first year of their age," or that "in the first five months of its existence, that is, from April to August, both inclusive, it reaches, in favourable circumstances, to about eight pounds in weight, or grows at the average rate of about 1 lb. 9½ oz. a month; that from September following to March, seven months, it acquires seven pounds additional weight, which is at the average rate of about 1 lb. 1¾ oz. per month; and lastly, that through the next twelve months it gains ten pounds more, or weighs thirty-five pounds, which is somewhat more than 13½ oz. per month."

Fleming (*History of British Animals*, 1828, page 179) speaking of the young of the salmon, remarks, "the fry leave the spawning groove about March, retire to pools, and proceed

according to circumstances in myriads along the easy water at the margin of the river, with their heads against the stream, until they reach the tide in the estuary, where, like the kelts, which frequently go down at the same time, they retire to the deepest part of the channel and disappear in the sea. These samlets, smoults, or smouts, are regarded by many as re-appearing in the estuaries a few months afterwards in the character of 'grilses,' of from three pounds to four pounds weight, according to the lateness of the season."

Sir Humphry Davy (*Salmonia*, 1832, page 68) considered par to be hybrid offspring of a salmon and a trout; also that "pars are exceedingly numerous in those rivers where they are found, which are never separated from the sea by impassable falls; from which I think it is possible that they are produced by a cross between sea and river trout," (page 70.)

Stoddart (*Scottish Angler*, 1831) strenuously advocated the theory that par are the young of the salmon.

Mr Buist (*Quarterly Journal of Agriculture*, 1832,) observed "the par is a compact fish, with firm scales, small head and eye, and from every appearance a fish come to maturity. The smolt is evidently a young tender fish, its scales come off with the slightest touch; its head and eyes are large, like other young creatures that are destined to be of a much greater size. . . . But the greatest and most decided difference is this, that pars are found in our rivers *at all seasons of the year*, and 'smolts,' or what we reckon salmon fry, *only* from March to about the *middle of June*. The difference between the fish, even in this respect, is almost sufficient to prove that they are not the same species."

Sir W. Jardine* says of the *Salmo salmulus*, or par, "the greatest uncertainty, however, latterly resolved itself into whether the par was distinct, or a variety, or young of the common trout, *S. fario*. With the migratory salmon it has no connection whatever. "In the markings they are so distinct as to be at once separated from the trout by any observer." "I have no hesitation in considering the par not only distinct,

* "Edinburgh New Philos. Journal, 1835, page 56.

but one of the best and most constantly marked species we have, and that it ought to remain in our system as the *S. salmulus* of RAY." He also says, "from the *migratory salmon* it is separated entirely by its habits. The correct distinguishing marks to be seen by a person who has not leisure to make a minute examination are the great size of the pectoral fins, the shortness of the maxillary bones, and consequently small gape, and the narrow breadth between the rami of the lower law."*

JENYNS† gives the *Salmo salmulus*, which he remarks is now pretty well ascertained to be a distinct species, always remaining of a small size. It is called in some places a "par," in others a "skirling" or "brandling." According to Dr HEYSHAM (*Catalogue of the Animals of Cumberland.* page 31) the adult fish go down to the sea after spawning, which takes place, as in the other migratory species of this genus, in the depth of winter.

Sir JOHN RICHARDSON (*Encyclopedia Britannica*, Ed. 1835, page 205) says, "the ova continue covered by the gravel during the winter, and begin to vivify from about the end of March to the commencement of April. The fry remove from under the gravel when nearly an inch in length, with the ovum still attached; and at this period, if the spawning bed or furrow be turned up, it will appear in motion. When disengaged from the ova the fish increase in size more rapidly, and about the end of April and during May commence and perform their first migration or journey to the sea. At this time they are from four to six inches in length."

YARRELL (*History of British Fishes*, Edition 1, 1836, i. page 15,) observes of the fry of the various species of *Salmonidæ* that "it is this similarity in marking and appearance of the fry which has caused the difficulty in distinguishing between the various species when so young; and experimenters, believing they had marked young par only, have been surprised to find some of their marked fish return as grilse, young bull-trout, or whitling, salmon-trout, river-trout, and true par." "The laspring of some rivers is the young of the true salmon, but in

* "Berwickshire Naturalists' Field Club I, page 84.
† "Manual of British Vertebrate Animals," 1835, page 426.

others, as I know from having had specimens sent me, the laspring is really a par." At page 42 he gives a good figure of the par, and remarks "that this little fish, one of the smallest of the British *Salmonidæ*, has given rise to more discussion than any other species of the genus." Continuing that it has frequently been insisted upon as the young of the salmon, and local regulations have as generally been invoked for its preservation. That the par is not the young of the salmon, or indeed of any other of the larger species of *Salmonidæ*, as still considered by some, is sufficiently obvious from the circumstance that pars by hundreds may be taken in the rivers all the summer, long after the fry of the year of the larger migratory species have gone down to the sea; and the greater part of those pars, taken even in autumn, do not exceed five inches in length, when no example of the young of the salmon can be found under sixteen or eighteen inches, and the young of the bull-trout and salmon-trout are large in proportion." He also alludes to an opinion which prevailed that pars were hybrids, and all of them males. Heysham found 196 females out of 395. Yarrell likewise remarks the 'skegger' of the Thames is the par or samlet."

Russel remarks that about ten years before what were really the first decisive experiments, (1824 or 1825.) Mr Scrope (*Days and Nights of Salmon Fishing*) wrote a long letter to the Right Hon. T. F. Kennedy, M.P., in which the theory or rather fact that the par is the young of the salmon was stated with positiveness and argued with great clearness and force. Also "the finding in spring of the distinctive marks of the par under the silver scales of the smolt."

About eight years later, and still previous to the decisive experiments, he continued, "James Hogg, the Ettrick Shepherd, gave the world some very good reasons of his own for holding the par to be the young of the salmon, reasons founded on observation and experience, partly on his having observed the gradual assumption of the migratory dress by the par in the spring months, partly on his having caught a grilse fish which he had marked when a par, or when in their transition-state

from par to smolt." Previously, he had held a different opinion, believing the par not to be the young of the salmon, but was convinced to the contrary by Mr SHARPE.

SHAW (*Edinburgh New Philosoph Journal*, 1836, page 99) communicated certain experiments which he instituted on the par as to what its relations really were, for he had always believed it to be the young of the salmon. On July 11th, 1833, he caught seven pars, and put them into a pond supplied with a stream of wholesome water. In April, 1834, they became of a beautiful blue on the back, and a delicate silvery appearance on the sides, while the scales came readily off on their being handled. In March, 1835, he took twelve more pars, averaging six inches each in length, from the river which took on the smolt dress in April, 1835, which species he concluded these fish to be. "The salmon fry has hitherto been erroneously supposed to grow to the size of six or eight inches in as many weeks, and to take its departure for the sea after this brief period has elapsed. The rapidity with which the par of two years old assumes the appearance of the salmon-fry has led to this error, the par taking about the same time to perfect its new dress, as the young salmon is supposed to take in attaining the growth at which it has arrived at the period of its migration." In May, 1834, he caught some young about one inch in length with a gauze net, and put them into two separate ponds provided with a proper supply of running water. In May, 1835, they averaged 3½ inches long, and corresponded to the par of the river, and in the second week of that month assumed the smolt living and measured about 6½ inches in length each. On January 10th, 1836, he saw a female salmon about 16lbs. weight, and two males of at least 25lbs. engaged in depositing their spawn, and three days subsequently he obtained ova from the spot where he had observed these fishes, and which ova he placed in gravel under a stream of pure spring water. On April 8th he found they had hatched, and after 140 days more corresponded with the little fishes he had taken in May, 1834. In January, 1836, he took a male and female salmon, apparently from 16lbs. to 20lbs. in weight, and which were in the act of spawning, he

dug a trench in the gravel, through which he caused a current of water to flow, two inches deep. He then had these two living fishes held in this trench side by side, while with the hands he pressed the ova and milt out of their bodies, which mixed freely together in the stream. A few minutes subsequently he removed the ova to a stream to which no other fish had access, and ninety-four days subsequently young fish were hatched.

Passing on to a paper read by Mr Shaw before the Royal Society of Edinburgh, December 18th, 1837, he observed that his former paper on ova taken from the Nith had been objected to, as there was not sufficient evidence that these were the eggs of the salmon, the same stream being accessible to other fish. So he repeated his former experiments, preserving the skins of the parent fish, also laying his experimental basins dry, not only for the purpose of removing any young fish which might remain, but likewise to fit them up on such a principle as would exclude the possibility of confusion, either from the overflowing of the ponds themselves, or from the flooding of the river Nith, on the banks of which they were situated. On January 4th, 1837, he captured a pair of salmon engaged in depositing their spawn. Before proceeding to take the fish he formed a small trench in the shingle at the edge of the river, through which he directed a small stream of water two inches deep. At the end of this trench he placed an earthenware basin of considerable size for the purpose of ultimately receiving the ova. Having drawn the fish ashore he placed the female, still alive, in the trench, and pressed from the body a quantity of the ova. Then the milt was similarly obtained from the male, thoroughly impregnating the eggs. The eggs were now transferred to the earthenware basin, and deposited in a stream connected with a pond previously formed for its reception. On the 28th of April, or 114 days after being removed from the parent fish, the eggs hatched. On May 24th, or twenty-seven days after being hatched, the young had absorbed the yelk-sac; they died a few days subsequently, caused, he supposed, from a deposition of mud, the same result having been more than once produced when the pond had not been sufficiently embedded with gravel.

The next experiment was conducted with more success. The parent fish were similarly captured on January 27th, 1837, subsequently killed, and their skins preserved. The male when taken weighed 16lbs., and the female 8lbs. On May 7th, or 101 days after removal from the parent fish, the eggs hatched. He gave illustrations, life size, from examples ten days old, forty-eight days, two months, and six months of age, while no marked difference could be observed between them and the par in the river of a corresponding age.

Parnell ("Fishes of the District of the Forth," 1838, page 298) gives the *Salmo salmulus*, or par, as a distinct species observing "that if we compare a young *salmon* of eight inches in length with a *par* of equal size, both taken from the same river in the month of May, we shall find them to differ in the following respects;" and then follow his reasons for this opinion. He remarks that "it is generally supposed that those small fish, from four to five inches in length, which are found so plentiful in many rivers during the autumn months, and which are marked on the sides with from ten to eleven transverse dusky bands, and a black spot on each gill-cover, are either all pars or the young of the salmon. But from a minute examination of several hundreds of these fish, taken in various rivers in England and Scotland, I am induced to consider them as not all of one species, but the young of various species or varieties of migratory trout, in company with the young of the salmon, with the *Salmo salmulus* or par, and with different varieties of the common fresh-water trout; all of which have received the names of *Heppers, Brandlings, Samlets, Fingerlings, Gravellings, Lasprings, Skirlings*, and *Sparlings*." "There are still great doubts as to the *par* being a migratory species, since no instance has been recorded of its capture in the sea. Nor does it appear to me to be so common a fish as is generally considered."

Thompson ("Natural History of Ireland," 1856, being a reprint of many of his papers, written at various dates) terms the par a gravelling, the young of the salmon (vol. iv., page 143). "The remark of Pennant, that 'the adipose fin is

never tipped with red, nor is the edge of the anal white,' can only be considered as generally correct. Two of my pars do, though very faintly, show red on the adipose fin, and one half of them have the base of the anal fin white." "The three most striking characters of the par in contradistinction to the common trout, are—its tail being more forked, its having only two or three spots on the *opercula*, and its want of *dark-coloured* spots beneath the lateral line. The pectoral fin of the par is larger, and the hinder portion of the operculum less angular than in the common trout."

Yarrell ("British Fishes," 1841, ii., page 14, &c.) says, "In order to prevent any misconception of the terms employed, I shall speak of the young salmon of the first year as a *pink;* on its second year, until it goes to sea, as a *smolt;* in the autumn of the second year, as *salmon-peal* or *grilse;* and afterwards as adult salmon." "Mr Shaw's experiments have gone very far towards convincing many that the par, as a distinct species, does not exist" (page 84).

In the "List of the Specimens of British Animals in the Collection of the British Museum," "Fish" was written by Mr Adam White in 1851, and at page 76 the par is given as the young of the salmon and sea trouts.

Mr Young, the Manager of the Duke of Sutherland's Fisheries, was experimenting as to whether par were or were not the young of the salmon, at the same time as Mr Shaw, and he asserted that they certainly were the young of *Salmo salar.* In a letter from Invershin, dated January, 1853, and which was published, he observed: "The fry remain in the river one whole year, from the time they are hatched to the time they assume their silvery coat and take their first departure to the sea. All the experiments we have made on the ova and fry of the salmon have exactly corresponded to the same effect, and none of them have taken longer in arriving at the smolt than the first year."

In the evidence given in the case of Galbraith *versus* Shaw, at Dunblaine in January, 1858, some river watchers deposed as follows:—"I have not seen a female par with spawn

at all. The male par will spawn, or, as I mean, have milt the first year of its existence." "I have seen smolt go to sea in shoals. I wont swear that I ever saw par going down with them." "Par sometimes remain more than a year in the river after they are hatched. They then become smolts with a silvery skin, and in that state descend to the sea. When a smolt is stripped of its scales, it is a par below" (James Mathie). "The marks of a par are finger marks. The number of marks vary. I have found eleven, and I have found sixteen. The pars thus observed were of the same ages. The number of marks does not depend on the size. I never saw par with fewer than eleven. I have never seen par taken from any river but the Tay." "The par of the trout has the dead fin orange; the rudder fin is white at the bottom and yellow at the top. They have not so many par marks as the par. I do not think they have ever more than six marks" (Peter Marshall). "There is not a pool or stream on the Teith where par are not (I confine myself to smolts). Every pool at a certain time has par. It is my opinion that pars are the fry of salmon. They assume the silvery scale when they go down the river. I have seen kelts taking on the same silvery coat at repeated times, in the end of March and April, preparing to descend the river; but before this I have seen them of a different colour" (James Greenhorn).

Of the 1854 salmon hatching at Stormontfield, Mr Buist reported "that the first of the fry that left the pond as smolts in 1855 was on the 19th of May; the last on the 7th of June. No more left that year. The first of the same brood which remained as par all last season assumed the smolt scales in August, 1856. The first division went off on the 28th of April, and the last on the 26th of May. In both years they went off daily in divisions from the first to the last day. About 1,300 were marked in 1855, and several returned, as stated in my report. The number marked in 1856 was 300 with rings, and 800 with cuts in the tail. Taking one in each hundred as marked it may be reckoned thus:—Left the pond in 1855, 130,000; in 1856, 100,000; total, 230,000." Although many

grilse were reported to the superintendent as captured, having this year's mark, not one having the ring was among those taken. The grilse in 1856 were very numerous, but marked ones were not detected. A few of the fry that left the pond in May or June, 1855, were reported as having been caught this season as salmon.

Dr J. Davy ("Physiological Researches," 1863, page 221) concludes "that a par—a distinct species—is a creature of the imagination, and that the idea of such a species ought to be opposed, both as founded in error, and as affording a pretence to allow of the wasteful, mischievous capture of the salmon and sea-trout fry."

Russel ("The Salmon," 1864, page 33) observes that the chief questions are, or have been:—1st. Is the par the young of the salmon in earliest infancy? 2nd. At what age does the smolt emigrate to salt water? 3rd. After what length of absence does the emigrant return to fresh water? 4th. In what state does he return, "grilse or salmon?" Continuing, "that the par is the infant young of the salmon was a fact so clear, or a conclusion so inevitable, before the experiments (Shaw's) were made, that it would not be hard to conceive how it could ever have been in doubt. Were it not that, even after the experiments have furnished the most ample demonstration, there are still to be found a considerable number of people who, instead of having been convinced, have only been enraged." "Every schoolboy on the banks of the Tweed (where almost alone the *S. salar* and *S. eriox* are found together in plenty) knows at a glance the difference between the smolt of the salmon and of the bull-trout—the black-fin and the orange-fin."

Couch ("British Fishes," iv., 1864, page 245) observed, "The question at present, therefore, is not whether the young of the salmon—and, we may add, of some others of the same family—may not remain in fresh water for more than a year, during which they may bear on the sides a series of dusky marks at this time, denominated Par-bands, but whether there be not also a distinct species which bears those marks, and which, by something like arrested development, is never

deprived of them." "Mr SHAW's conclusions, in some particulars, appear to be far from satisfactory; and, as regards the true nature of a fish he terms the par, the question appears to be exactly where he found it."

BERTRAM ("The Harvest of the Sea," 1865, page 105) observed: "Indeed, the experiments conducted at the Stormontfield ponds have conclusively settled the long-fought battle of the par, and proved indisputably that the par is the young of the salmon, that it becomes transformed to a smolt, grows into a grilse, and ultimately attains the honour of full-grown salmonhood. The anomaly in the growth of the par was also attempted to be solved at Stormontfield, but without success. In November and December, 1857, provision was made for hatching in separate compartments the artificially impregnated ova of—(1.) par and salmon; (2.) grilse and salmon; (3.) grilse pure; (4.) salmon pure. It was found, when the young of these different matches came to be examined early in April, 1859, that the sizes of each kind varied a little; Mr BUIST, the superintendent of fisheries, informing us that—(1st.) the produce of the salmon with salmon are four inches in length; (2nd.) grilse with salmon, 3½ inches; (3rd.) grilse with grilse, 3½ inches; (4th.) par with grilse, three inches; (5th.) smolt from large pond, five inches. These results, of a varied manipulation, never got a fair chance of being of use as a proof in the disputation; for, owing to the limited extent of the ponds at the time, the experiments had to be matured in such small boxes or ponds as evidently tended to stunt the growth of the fish."

Dr GÜNTHER ("Catalogue of the Fishes of the British Museum," vi., 1866, pp. 11-34) places the *Salmulus* of WILLOUGHBY as the young of a variety of sea trout, which he termed *S. cambricus;* while the *Salmulus* of RAY he considered an immature salmon, observing in a note that "under these names the young not only of the salmon, but also of other salmonoids, have been described." RAY's description is almost verbally identical with that of WILLOUGHBY; and in the "Introduction to the Study of Fishes," by Dr GÜNTHER, 1880, it is observed

that "the Historia Piscium," which bears WILLOUGHBY's name on the title page, and was edited by RAY, is clearly their joint production." He also says: "SHAW has demonstrated in the most conclusive manner that those small Salmonoids, generally called *Par*, are the offspring of the salmon, and that many males, from seven to eight inches long, have the sexual organs fully developed, and that their milt has all the impregnating properties of the seminal fluid of a much older and larger fish. That this Par is not a distinct species—as has lately been again maintained by COUCH—is further proved by the circumstance that these sexually mature Pars are absolutely identical in their zoological characters with the immature Pars, which are undoubtedly young Salmon, and that no Par has ever been found with mature ova. But whether these Par produce normal Salmon, impregnating the ova of female Salmon, or mingle with the River-trout, or whether they continue to grow and propagate their species as true Salmon, are questions which remain to be answered."

In 1869 commenced the case of the Tay Fishery Board *versus* MILLER, who was accused "in so far as, upon Saturday, the 26th June, 1869, or about that time, the said ROBERT MILLER had in his possession nine smolts or salmon fry." First decided against the Fishery Board, who appealed, when the case was remitted back to the sheriff to enquire whether par was salmon fry? On the 8th of October, 1869, the sheriff found that "the defendant had in his possession certain fish commonly known as pars, but which are not named in the prohibitory and penal clauses libelled; but finding it not proved that he then had any fish known as smolts, the only fish named in the same section of the statute libelled, and declines to enquire and decide the question in natural science, whether par be, or be not, salmon fry." The Sheriff-substitute, July 12th, 1870, "finds it not proved that, in the popular and well-understood sense, any of the pars found in the possession of the accused on the day libelled were salmon fry." He, however, admitted that the evidence as a naturalist "would have led him to decide, as a point of science, that par, or at least

certain of that family, were the young of salmon." Another appeal was now made on July 20th, 1870, that as the pars "were the young of salmon, or salmon fry, the Sheriff-substitute ought to have given effect to said proof by a judgment against the respondent." The case was tried at Perth, September 7th, 1870, and the defendant was finally convicted.

June 4th, 1872, an individual was summoned before the Sheriff in so far as, on the 24th of April last, he did, on the right bank of the river Allan, by means of a rod and line, take or have in his possession six smolts or salmon fry. As the first witness observed, salmon fry meant the smolt of the salmon proper. The yellow-fin was the sea-trout smolt. One witness, Mr G. Young, of Berwick, deposed that the orange-fins of the Tweed were identical with the yellow-fins of the Allan, and that they were the par or young of the sea-trout. Very extensive experiments had been made in the river with regard to these fish. He was a Tweed Commissioner, and also belonged to the experimental committee. They had marked these fish for a great number of years, and had traced them into all stages of their growth, from the egg to the full-grown bull or sea-trout. The orange-fin is the young of the sea-trout. They were known as "black-tails," just before passing from the orange-fin into the whitling or bull trout. Mr Bruce remarked: "They have par to account for the young salmon, the small yellow trout to account for the young of the yellow trout, and it seemed to him that the yellow-fin could be nothing else than the young of the sea-trout." Dr Günther deposed that "there is a distinction between the young of *Salmo salar* (the salmon) and a member of the *Farios* (trout). In the par of the former I have counted as many as nine or ten cross bars, and in the latter only six or seven." "I am not quite sure but that milt and ova might be found in a hybrid. It has been found in pars, and my theory is that where this is so, the first is the product of a hen salmon and a male river trout, as it was frequently found that a hen salmon was spawning on the same gravel bed with a male river trout. This hybrid would come to maturity sooner than a pure-bred salmon,

and thus give the appearance of ova or milt being found in the par."

Mr Buist (*Stormontfield's Piscicultural Experiments*, 1867,) altered his mind with respect to pars, due to his having been engaged at the Stormontfield ponds, where experiments were being carried on, and which gave him an opportunity of observing the transformations in the par with age. After remarking that at one time he was an advocate of the popular dogma that the par was a distinct fish by itself, one proof being that in the month of November, 1832, a male par had been brought to him with the milt flowing out. "The par in question was really the young salmon of the second year, which had not then gone to the sea. At Stormontfield we have repeatedly seen a young salmon, which remained in the rearing pond till the time of migration in the second year, though not the size of a man's finger, yet with such a state of milt in the breeding season that we have impregnated eggs of the full-grown salmon with it, and thereby produced young fish. Such is not the case with the sister fish of the second year in the pond, as not even the rudiments of roe can be traced in them."

I do not intend referring further than I have, at present, to the par of the sea trout and the experiments which have been tried with reference to it, except to observe that on May 17th, 1874, 133 fish, averaging about seven or eight inches in length, were selected as good examples of "orange-fins," and placed in artificial ponds at Carham. On May 2nd, 1879, after five years' confinement, 30 of them were weighed, measured, and marked, and returned to the Tweed. On June 4th one of these fish, marked with silver wire, was captured near Birgham, on June 4th or 5th, and sent to Mr Brotherston, of Kelso, and was a common trout; and he states another was taken near the same place, on or about July 17th. The question of identity or the reverse of all the forms of fresh water and sea trout as one species, subject to great variation in races and even individuals, is too long to be treated of in this place in its various bearings.

I will now briefly allude to the investigations carried on by Sir James Ramsay Gibson-Maitland, Bart., most of which

experiments he has kindly allowed me to be present at, and also furnished me with specimens at various times for my collection of fishes.

In December, 1880, the owner of Howietoun obtained eggs and milt from salmon in the Teith, which were hatched in March, 1881: the young were transferred to a plank-lined pond, 100 by 15 feet, eight feet deep in its centre and six and a half on either side, while one and a half millions of gallons of water a day passed through it. In July, 1883, there were par and smolts and in 1884 eggs were obtained from grilse like smolts, and which were hatched in the establishment.

I do not propose in this paper discussing grilse, but I wish to draw attention to the variations observed in the scales of par, smolts or grilse and salmon.

DESCRIPTION OF PLATE

Upper Figure.—Scale of a par 32 months old, taken from the row just above the lateral line and between it and the adipose fin; the scale is magnified 7½ times.

Middle Figure.—Scale of a grilse 34 months old, taken from the same locality and magnified 12 times.

Lowest Figure.—Scale of a 16 lb. salmon, taken from the same locality and magnified 12 times.