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NOTE.

The object which the Society have in view in publishing their Proceedings is to give an immediate and succinct account of the scientific and other business transacted at their meetings to the members and the general public. The various communications are supplied by the authors themselves, who are alone responsible for the facts and reasonings contained therein.

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PROCEEDINGS

OF

THE LITERARY AND PHILOSOPHICAL SOCIETY.

Ordinary Meeting, October 5th, 1875.

EDWARD SCHUNCK, Ph.D., F.R.S., &c., President, in the Chair.

Mr. Thomas Mackereth, F.R.A.S., F.M.S., was elected an Ordinary Member of the Society.

"Glue Battery," by Dr. J. P. JOULE, F.R.S., &c.

If sulphate of zinc or sulphate of copper be dissolved in solution of gelatine and then carefully dried, an elastic solid is produced holding the salt in combination, which softens on the application of heat. I have taken advantage of this circumstance to form a voltaic couple which illustrates Faraday's discovery of the necessity of liquefaction for electrolysis, and which also may not be without some practical advantages.

I paint pieces of zinc with glue impregnated with salt of zinc, and pieces of copper with glue charged with sulphate of copper, dry, and lay them together in series. The pile thus formed is inert when cold, but capable of giving a good current when heated, as will be seen from the following results obtained with a single couple in connexion with a delicate galvanometer:

Temp. Fahr.	Deflection.	Temp. Fahr.	Deflection.
64°	0°	150°	5° 50′
70°	0° 40′	160°	7° 20′
80°	1° 10′	170°	8° 10′
90°	1° 40′	180°	10° 20′
110°	2° 50′	190°	17° 40′
130°	3° 0′	200°	43° 0′
140°	4° 40′		

After the lapse of three years I find that the above couple has retained its powers almost unimpaired.

E. W. Binney, F.R.S., V.P., said that many years ago, when he first came to Manchester, the red sandstone found under the city was known by the name of the Upper New Red Sandstone, the lowest division of the Trias and the equivalent of the Bunter. The authorities of the Geological Survey have divided it into Lower Soft Red Sandstone, Pebble Beds, and Upper Soft Red Sandstone; but the Pebble Beds are the deposits chiefly found under Manchester. Superior to this sandstone he had seen a deposit of red marls which he thought resembled the red marls of Cheshire, and at page 37 of the 1st vol. of the Transactions of the Manchester Geological Society he states that "this deposit, extending over so great a portion of the neighbouring county of Chester and reaching to a great thickness in the salt beds, is seldom to be seen in the south east of Lancashire. The only place where I have observed it is on the south of the town along the line of the Oxford Road from All Saints' Church to St. Peter's Square. After going through the diluvial clay a thin band of two feet in thickness occurs. In Chepstow Street leading out of Oxford Road this bed is between four and five feet in thickness. In the middle of it occurs a light coloured layer resembling fullers' earth in appearance, which briskly effervesces when treated with dilute hydrochloric acid. The lower part of the marl becomes arenaceous and passes

gradually into the upper sandstone. Both rocks dip to the W.S.W. at an angle of 8°. The marls here found are of a dark red colour, variegated by streaks and patches of green and yellow. They effervesce feebly with acids. No clearly recognized organic remains have been found in them—a circular concretion something resembling the cast of an ammonite was found in Chepstow Street." Since this notice was written, about 35 years ago, nothing has appeared respecting these marls. During the past summer he had noticed some shafts being sunk on the site of the intended new railway station of the Cheshire Lines in Back Newberry and Redford streets. In the first named locality the following section was met with :—

Till or Brick Clay	15ft.
Red and Variegated Marl	27
	42

In the last named

Till	15ft.
Red Marl.....	41
	56

The red marls in their lower portions gradually became arenaceous and finally passed into the underlying red sand stone. In the pebble beds strata of red marls of one to two feet in thickness are sometimes met with, but nothing like a deposit of 40 feet. As the line of the Great Irwell fault of above 3,000 feet in throw runs a little to the south of the district where the marls are met with it is probable that these are a lower portion of the Red Marls of Cheshire lying above the Bunter beds of the Trias. He brought the matter before the Society for the purpose of directing the attention of the members to any excavations they might observe, as it was desirable that no facts concerning the rocks under our city should escape notice, and as so few opportunities occur for observing this deposit of marls no opportunity for examining them should be lost.

Ordinary Meeting, October 19th, 1875.

EDWARD SCHUNGK, Ph.D., F.R.S., &c., President, in the Chair.

"On some Reactions of Bromine and Iodine," by Professor C. SCHORLEMMER, F.R.S.

Although it is well known that iodine dissolves in chloroform and some other liquids, such as carbon-sulphide and petroleum-naphtha, with a fine purple and bromine with a yellow colour, it seems not to be known that, under certain conditions, a colourless solution may be obtained containing both these elements in the free state.

Thus on adding dilute chlorine water drop by drop to a weak solution of potassium iodide and bromide, containing an excess of the latter, and shaking the liquid at the same time with chloroform, the purple colour of the iodine makes first its appearance, but gradually becomes fainter and at last disappears completely. It is, however, not easy to hit exactly the point, when the chloroform becomes quite colourless, but this is readily effected by adding so much chlorine water that the chloroform assumes a faint yellow tint, and then shaking the liquid with a cold and dilute solution of sodium bicarbonate, which must be carefully added drop by drop. It is easily proved that the colourless solution thus formed contains both free bromine and iodine, for on adding more bicarbonate, in order to remove the free bromine, the purple colour gradually appears again.

I am not able as yet to explain these facts; it is not a case of two complementary colours neutralising each other as I first assumed; for on mixing dilute solutions of the two elements in dry chloroform no colourless solution can be obtained. It seems that the presence of water has something

to do with it, for on adding the solution of bromine to that of chloroform until the purple is changed into a light brown, then shaking well with water, the colour of the chloroform becomes much paler and even disappears almost completely.

E. W. Binney, V.P., F.R.S, said that at the last meeting he had stated the circumstance of an urn containing bronze coins having been discovered under a peat moss. He now exhibited two small coins of bronze, about half an inch in diameter, evidently Roman from the figures on them, and most probably of the reign of Otho. They were found sixty years since under a peat bog of fifteen feet in depth, in an earthenware urn buried in the upper red marl of Misterton Car, in Notts, which forms the southern portion of the Level of Hatfield Chace, a large turf moss on the borders of the counties of York, Lincoln, and Nottingham. Some hundred coins were in the urn, and the two in his possession were presented to him about fifty years since by his relative the late Mrs. Joseph Hickson of East Stockwith, on whose property they were met with, and who furnished him with the above particulars. In the peat under which they occurred numbers of large oak and yew trees, with their roots attached to them, were as thickly placed as they could have grown on dry and strong soil. At the period when the urn was deposited, the spot was a dense forest, which was probably destroyed by the drainage of the district having been impeded by the raising of the beds of the rivers Trent, Ouse, and Idle, and thus causing the formation of the bog. The Dutch, under the direction of Sir Cornelius Vermuyden, and more modern drainers, have succeeded in bringing the land into a state fit for corn growing, but not capable of producing such oaks and yews as are now found, with their roots attached to them, lying in the peat.

"Notes bearing on Mathematical History," by Sir JAMES COCKLE, F.R.S., Corresponding Member of the Society.

1. To the list of Professor Boole's writings which follows the preface to the Supplementary Volume of his "Differential Equations" [2nd (posthumous) ed., 1865, pp. viii—xi] may be added a paper entitled "Mr. Boole's theory of the mathematical basis of logic," published in the *Mechanics' Magazine* (1848, vol. xlix, pp. 254-255).

2. Mr. Blissard in his "theory of generic equations" (*Q. J. of Math.* vol. iv, p. 279; vol. v, pp. 58 and 185, see also pp. 184 and 325) has applied "representative notation" very extensively. Professor J. R. Young had noticed (*Mech. Mag.*, 1847, vol. xlvii, p. 627) that the law of Bernoulli's numbers is expressed by

$$(1 + B)^n - B_n = 0$$

if we write the exponents of B below instead of above that symbol. Judging from what purports to be an examination paper, I see that Prof. Young, examining for the Andrews Scholarship, 1851, at University College, London, again noticed (in question 7) the law.

3. In *Notes and Queries* (1854, vol. x, p. 48; see also p. 191; and 2nd Ser. vol. viii, p. 465, vol. ix, p. 340, vol. x, p. 162; and 4th Ser. vol. ii, p. 316) I long ago pointed out that Barocius, in the margin of p. 264 of his *Proclus* (1560) cites the *Geometricæ enarrationes* of Geminus, and I suggested that there might yet be some hope of recovering that work. In a comment (*ib.* 2nd Ser. vol. ix, p. 449) on something I had said, De Morgan remarked that he took "enarrationum" as a printer's mistake for "effectionum," if Heilbronner were right; adding that if there be, as both Petavius and Heilbronner seem to state, a printed catalogue of the manuscripts of Barocius, it would be desirable to revive the knowledge of it. De Morgan states that Petavius is the authority for manuscripts of Barocius being brought to England, and that it may be that a manuscript book of

Geminus, which Petavius describes as "nondum editus," yet exists in some English library. One of two strange things must have happened (see De Morgan, *ib.* p. 450), viz. either the minute Petavius omitted the title of the work, if it were given; or Heilbronner preserved a title from some other source, if it were not. I am not aware that the manuscript has been discovered.

4. Lagrange, at page 2 of vol. i of his "Mécanique Analitique" (1811), observes that the laws of statics are founded on general principles which may be reduced to three; that of the lever, that of the composition of forces, and that of virtual velocities. He says (*ib.* p. 18, No. 14) that the principle of the lever is the only one which has the advantage of being founded on the nature of equilibrium considered in itself, and as a state independent of motion.

5. Lagrange (*ib.* p. 20) says that it does not appear that the ancients knew of the law of virtual velocities. From what is said by Whewell in his "History of the Inductive Sciences" (1837, vol. ii, pp. 39 and 42; vol. i, pp. 69, 81, 82 and 94) it seems that the law, so far as it relates to the lever, was known to Aristotle. Whewell considered the physical philosophy of Aristotle (*ib.* i, 25) and of the Greeks (*ib.* 33) as an utter failure. He apparently regarded the doctrine of the lever (see vol. ii, p. 59; vol. i, chap. I, sect. 1, p. 91) with greater favour than that of virtual velocities (see vol. ii, chap. II, sect. 4, p. 39), in connection with which he makes no special mention of Lagrange (see vol. ii, p. 120). Professor Cayley (*Messenger*, N. S., vol. iii, p. 1) has given a dissertation "On the general equation of virtual velocities."

6, There are two modes of approaching the parallelogram of forces. First, we may from the composition of motions. through the second law of motion, pass to the composition of forces. Thomson and Tait, fortified by the example of Newton (see their 'Treatise,' &c., vol. i, pp. 181, 182, § 255—257) have followed this mode, which they believe

to contain the most philosophical foundation for statics. Lagrange, whose writings are a mine of historical information, says ('Méc. Anal.' i, 13) that the ancients knew the composition of motions, as we see by some passages of Aristotle, in his Mechanical Questions; and that the geometers especially have employed it for the description of curves, as, Archimedes for the spiral, Nicomedes for the conchoid, &c.

7. Secondly, we may seek to arrive at the composition of pressures, independently of the second law of motion, by processes which are valid whether that law be a law of nature or not, and which would be valid even if we had not any conception of motion, and which indeed do not render it necessary to consider whether pressure does or does not tend to produce motion. Lagrange ('Méc. An.' i, 19) thinks that the principle of the composition of forces, in being separated from that of the composition of motions, loses its principal advantages; and he, just before saying this, throws out a doubt as to whether a principle used by Daniel Bernoulli in his demonstration was altogether independent of the conception of motion. The whole subject of composition is discussed by De Morgan in his paper "On the General Principles of which the Composition or Aggregation of Forces is a consequence." (Camb. Trans. Vol X. Part II, 1859).

8. Lagrange ('Méc. An.' i, p. 14 No. 11) observes that, although the principles of the lever and of composition lead always to the same results, it is remarkable that the simplest case for the one becomes the most complicated for the other. He adds (*ib.* No. 12) that we can establish an immediate connection between these two principles by a theorem of Varignon. Newton's view is noticed by Lagrange (*ib.* No. 10).

9. Thomson and Tait have a special object ("Treatise" &c. vol. i, Preface p. v; p. 141 par. (f); p. 341 § 453), in reference to which Newton's proof may be the more appropriate or elegant. I here use the word "elegant" in the sense which

Austin, in his "Lectures on Jurisprudence" (vol. ii, p. 365) says it is used by the Roman lawyers. But there is much that is interesting in the other investigations on the subject.

10. Lagrange (*ib.* p. 29) uses the term "moment" in the sense which Galileo (*ib.* p. 20) gave it, viz: the product of the force into its virtual velocity; noticing however another (*ib.* p. 7) meaning viz. the product of the force into the arm of the lever by which it acts.

11. Whewell (Hist. Ind. Sci., i, 93), speaking of a "matter of obvious and universal experience," says

"This general fact is obvious, when we possess in our minds the ideas which are requisite to apprehend it clearly. When we are so prepared, the truth appears to be manifest, independent of experience, and is seen to be a rule to which experience must conform."

He seems (*ib.* ii, 25) to reiterate this opinion, which, if "appears to be manifest" be taken to mean "is self-evident," will hardly pass unquestioned.

12. Lagrange ('Méc. An.' i, 4, 5) tells us, in words which I translate as follows, to

"imagine a triangular plane loaded with two equal weights at the two ends of its base, and with a double weight at its vertex. This plane will evidently be in equilibrium, when supported by a straight line or fixed axis, which passes through the middle of the two sides of the triangle; for we may regard each of these sides as a lever loaded at its two ends with two equal weights, and which has its fulcrum on the axis which passes through its middle. Now we may contemplate this equilibrium in another manner, by regarding the base itself of the triangle as a lever of which the ends are loaded with two equal weights; and by imagining that there is a transverse lever which joins the vertex of the triangle and the middle of its base in the form of a T, and of which one end is loaded with the double weight placed at the vertex, and the other serves as the fulcrum of the lever which forms the base. It is evident that this last lever will be in equilibrium on the transverse lever which sustains it at its middle, and that the transverse lever will consequently be in equilibrium on the axis

on which the plane is already in equilibrium. But since the axis passes through the middle of the two sides of the triangle, it will pass also necessarily through the middle of the straight line drawn from the vertex of the triangle to the middle of its base; hence the transverse lever will have its fulcrum at the middle point, and must consequently be equally loaded at its two ends. Hence the load supported by the fulcrum of the lever which forms the base of the triangle, and which is loaded at its two ends with equal weights, will be equal to the double weight at the vertex, and consequently equal to the sum of the two weights."

13. Whewell in his "Mechanical Euclid" (2nd ed. p. 170) says that it will be found that Lagrange's proof, if distinctly stated, involves some such axiom as this:—that

"If two forces, acting at the extremities of a straight line, and a single force, acting at an intermediate point of the straight line, produce the same effect to turn a body about another line, the two forces produce at the intermediate point an effect equal to the single force."

He adds that though this axiom may be self-evident, it will hardly be considered as more simple than the proposition to be proved. Without discussing Whewell's criticism I observe that Lagrange ('Méc. An.' i, 16, 19) regards forces as quantities which can be added and subtracted, and which may be regarded (*ib.* p. 18) as weights. De Morgan (loc. cit.) seems to be of opinion that the proposition that the weight of the whole is equal to the sum of the weights of all the parts is known only by experience.

"Oakwal," near Brisbane,
Queensland, Australia,
July 22, 1875.

"Note on the Temperature of the Body during Physical Exertion," by M. M. Pattison Muir, F.R.S.E., Assistant Lecturer on Chemistry, Owens College.

In *Nature*, vol. xii, p. 132, appeared an account of Dr. Forel's observations on body-temperature during mountain

climbing, the general conclusion of which was that the temperature of the body *increases during* ascents or descents.

In the same journal, p. 165 of the same volume, Dr. Thorpe has published the results of observations made upon himself during an ascent of Mount Etna, from which it appears that he noticed a *small decrease* of temperature.

Dr. Anderson, however, *Nature*, vol. xii, p. 186, partially confirms the earlier experiments of Drs. Marcet and Lortet, who observed a *decrease of 3 or 4 degrees F.* in the temperature of the body during mountain ascents. The greatest fall recorded by Dr. Anderson amounts to 1°·6 F.

During the long vacation I carried out a few experiments upon my own body-temperature while rowing and while ascending a height.

The observations were made with a registering clinical thermometer, the bulb of which was placed in the mouth underneath the tongue. The bulb was allowed to remain in this situation during five minutes before the readings were noted.

EXPERIMENT I.

Initial temperature	98°·5 F.
After rowing for ½ hour	99°·05
After hard rowing for ¾ hours	98°·6
After resting ½ hour, eating two biscuits, and gently rowing for ¾ hours	99°

EXPERIMENT II.

Initial temperature	98°·4 F.
After ½ hour's hard rowing	99°
After 1 hour's „ „	98°·7

EXPERIMENT III.—Ascent of Goatfell.

	Time.	Height in Feet.	Temp.
Beginning ascent	1 p.m.	——	98°·8
Easy climbing. Warm	1·50	900	99°
Stiffer climb. Perspiring	2·30	1,750	99°·5
Hard climbing. Perspiring much	2·45	2,200	99°·2
Very hard climbing. „ „	3·0	2,750	99°
After descent of 2,500ft. Warm	4·0	——	99°·3

The observations were invariably taken *while actually rowing or climbing.*

These numbers are, in the main in accordance with those of Dr. Forel, and shew that a *slight increase* took place in my body-temperature during physical exertion. This increase was decidedly marked during the first half hour while rowing, and the first one and a-half hours while climbing, after which times a diminution of temperature took place, the final temperature being in no case, however, so low as the initial temperature.

Dr. Anderson, (loc. cit.) has attempted to explain the varying results of different observers by supposing that in some men the heat transformed into motion, and spent in doing work is restored by quick oxidation of material within the organism, while in the case of others whose power of oxidation is slower, no such equilibrium is maintained, and a decrease in body temperature consequently ensues. Looked at in this light the above numbers seem to show that during the earlier phases of physical exertion oxidation was more than sufficient to restore heat spent in doing work, but that as the work was continued and grew harder the excess of heat was gradually encroached upon. In the paper already cited from *Nature* (vol xii, p. 132) the abstractor shews that if body-temperature be taken as the exponent of internal work, then a greater increase ought to be observed during extra muscular work if unaccompanied by external work than if so accompanied. The results which I have obtained during canoeing bear out this theory. The following were the numbers :—

EXPERIMENT IV.

Initial temperature.....	98°·3 F.
After 20 minutes hard paddling.....	99°·4
After 30 „ „ „	99°·4

The external work done in propelling a light canoe through the water must be less than that needed for the

propulsion of a tolerably sized rowing boat—yet there is a very considerable amount of muscular work in maintaining the paddle in position, in the movements of the body, &c. Now the increase of temperature amounted to 1°·1 F., a much larger quantity than any noticed either during rowing or mountain climbing, where the *external* work is larger. Nor was the decrease which followed the first increase in the latter cases, noticeable while canoeing, probably because the external work was not continued long enough to make any great demand upon the internal heat.

MICROSCOPICAL AND NATURAL HISTORY SECTION.

October 11th, 1875.

JOSEPH BAXENDELL, F.R.A.S., in the Chair.

Mr. PLANT exhibited specimens of Locusta migratoria, found in Ordsall Lane and Peel Park, Salford, after the unusually strong equinoctial gales of the end of September.

"On the Hybrid British Heath, *Erica Watsoni*, Benth.," by CHARLES BAILEY, Esq.

Some weeks ago Mr. E. W. Nix, M.A., when in Cornwall with his brother Mr. Arthur Nix, collected, on a wet, boggy moor in the neighbourhood of Truro, a heath, whose habit and characters struck him as being different both from *Erica Tetralix* and *E. ciliaris*, and both gentlemen were satisfied it was a hybrid form. A small specimen which Mr. Edward Nix brought home with him to Manchester was shown to me for identification, and I had no doubt in naming it as the *Erica tetralici-ciliaris* of Syme (=*E. Watsoni* of Bentham).

Nine years ago I spent a whole day in a careful but unsuccessful search for this plant in the same neighbourhood, and it was with much pleasure I saw Mr. Nix's specimen this year, as the only examples of this hybrid which I had previously seen were those which Mr. H. C. Watson has from time to time distributed through the Botanical Exchange Club. Mr. Watson's plant came originally from Cornwall, where it was collected by the late Rev. C. A. Johns many years ago, and this plant having been transplanted to Mr. Watson's garden, has been the principal source from which British botanists have obtained specimens. Knowing the rarity of the occurrence of this plant in a wild state, I urged Mr. Nix to procure a root from the locality where he discovered it, and to the united kindness of this gentleman and his brother the Section is indebted for a sight of the living plant now exhibited.

From a paragraph in the report of the Botanical Exchange Club, which has appeared during the last three weeks, we learn that Mr. Cunnack of Helston, with Mr. Blow, also found this hybrid last year, on a barren moor between Truro and Penryn.

Mr. Nix's plant has affinities with both its supposed parents. It differs from *Erica Tetralix* in its longer and larger corolla, which is pear-shaped rather than urceolate in form through a rather sudden contraction in the uppermost half; in its having a herbaceous bract at the base of each pedicel; and in its more numerous barren branches.

It differs from *Erica ciliaris* in its less leafy habit and more spreading branches; in its more raceme-like inflorescence; and in its stamens, which have two minute, shortly-ciliate, subulate awns. Its leaves have more affinity with those of *E. ciliaris* both in shape and pubescence, but it is destitute of all glands at the extremities of the cilia of the margin of the leaf; this feature is the more noteworthy as the cilia in Mr. Watson's specimens are nearly all

glandular. The styles are very slightly exserted and the uppermost portion does not gradually widen upwards as in *E. ciliaris,* but it is abruptly capitate as in *E. Tetralix,* and the ovary is downy, not glabrous, but I cannot find on the whole plant a single ovary which has come to maturity.

The character by which the hybrid appears to be differentiated from its allies the most readily is taken from the anther, and more particularly by its awn-like appendages. The anthers of *E. Tetralix* possess two awns which are equal in length to the lobes of the anther, while the filament is united to the anther at the back just above the base of the lobes. The anthers of *E. ciliaris* are also attached by their bases to the filament, but there is no trace of any awns. In the hybrid plant however, the attachment of the filament is higher up the back of the papillose anther, so that the two lobes project much more than in the parent plants; from each side of the filament at its junction with the anther, there rises a slender awn whose length is only one-fourth that of the anther, and these two awns do not project beyond the lobes as they do in *Erica Tetralix.*

From a comparison of the specimens exhibited, it will be seen that Mr. Nix's plant comes nearer to *E. ciliaris* than do Mr. Watson's, particularly in the infloresence; but they agree perfectly in the character of the awns of the anther, as noted above. In habit it seems to have some affinity with *E. Mackaiana,* and it is nearer *E. Tetralix* than *E. Ciliaris* in this respect.

The habitat of the hybrid plant is described by Mr. Nix as decidedly boggy, and his observation of the Cornish localities of *E. ciliaris* leads him to conclude that it also flourishes best in a similarly moist station. Dr. Syme on the other hand gives "sandy heaths" as the character of the station of *E. ciliaris. Erica Tetralix* loves boggy land, and this seems to be the character of the station where *Erica tetralici-ciliaris* flourishes in some abundance.

The Connemara station for *Erica Mackaiana* is peculiar; according to my observation it occurs only on a small rocky eminence which rises out of a vast bog which is the home of *E. Tetralix*; as it grows in free flowering bushes a foot or more in height, it may readily be picked out from plants of *E. Tetralix*.

A series of British and Continental specimens of the heaths named in this communication now lie on the tables for comparison with the living plant.

Ordinary Meeting, November 2nd, 1875.

R. Angus Smith, Ph.D., F.R.S., &c., Vice-President, in the Chair.

Peter Spence, F.C.S., &c., exhibited a piece of 2 to 3 inch lead pipe in which the metal had been entirely transformed into galena, the crystalisation being visible through the whole of the specimen.

The shape of the lead pipe was unaltered, showing that the lead had not been exposed to a melting heat, no increase of bulk was visible, but the pipe was so brittle as to shiver with a blow. The circumstances in which this change was effected, as nearly as can be made out, were as follows.

The pipe had been used for the conveyance of gas ammoniacal water and was sunk under ground. It was in the vicinity of a furnace which heated the ground where it lay. It had been disused for some years but never taken up. When the ground where it lay had to be excavated for a new erection, it was found that there had been a considerable leak of gas water, as the ground for some space was impregnated with ammoniacal salts. About 25 per cent of the ammonia in gas water being sulphide, and the ground being warm, a constant atmosphere of sulphide of ammonium would surround the pipe, and this seems to have been the cause of the conversion of the lead into sulphide, as only that part of the pipe which was in the vicinity of the leak was found to be transformed.

"On the Principle of the Electro-Magnet constructed by Mr. John Faulkner," by Professor Osborne Reynolds, M.A.

The magnet which forms the subject of this paper consists of a soft iron bar with a flat plate attached to one end and surrounded by a coil of wire in the same way as the ordinary electro-magnet. Outside this coil is placed a tube of soft iron of the same length as that portion of the interior bar which projects beyond the plate; this tube has flat ends —one of which is in contact with the plate, while the other comes up flush with the end of the bar—so that a plate or keep placed over the end is in contact with both the bar and the cylinder. The magnet is excited in the ordinary way, by connecting the ends of the wire which forms the coil with the poles of a battery. When thus excited this magnet exhibits certain peculiarities as compared with a common magnet. In the first place the magnetic field is very limited, being confined to the space in front of the open end of the tube, there is little or no magnetism along the tube or at the closed end. The magnet retains its keep with greater force than the simple bar. Mr. Faulkner has some magnets of this kind which retain the keep with 100 times more force when the outer tube is on than when it is removed. The ratio of these retaining powers appears, however, to depend on the relative diameters of the bar and the tube; the larger the bar in proportion to the tube, the greater is the difference. Some magnets, made especially to test the relative powers, give an increase of only double as compared with the simple bar magnet. This magnet has a greater sustaining power than the horse-shoe magnet. This was shown by putting tubes round the poles of a horse-shoe magnet, by which means it was made to sustain greater weights than it would without the tubes.

The object of the paper was to suggest explanations of these phenomena. They were attributed to three principal causes.

1. The tube surrounding the bar unites the poles and converts the magnet into a kind of horse-shoe magnet, the

ends of the tube having the opposite polarity to those of the bar. If this were all, however, this magnet would not have any advantage over the horse-shoe magnet.

2. The close proximity of the tube to the bar enables the one pole to exert greater inductive action on the other, than in the case of the horse-shoe form.

3. The electro-magnetic action of both sides of the coil is utilised in the same manner as in the astatic galvanometer. The current converts the tube into a magnet of opposite polarity to the bar, and hence these two magnets act upon each other by induction, which their relative positions enables them to do with the greatest effect. It appears from the researches of Dr. Joule that the larger the bar inside the coil the less will be the intensity of magnetism exerted in it by the coil. While it may be shown that the smaller the tube—the closer it is to the coil—the greater will be the intensity of magnetism excited in it. Also the inductive action of the iron in the tube on that of the bar is inversely proportional to the square of the distance between them. Hence it follows that the effect of using the outside as well as the inside of the coil must increase rapidly as the diameter of the bar approximates to the internal diameter of the tube.

After the reading of the paper, Mr. FAULKNER exhibited some of his magnets; and by means of iron filings scattered on sheets of paper produced some very beautiful diagrams illustrating the effect of the outside tube on the magnetic field.

General Meeting, November 16th, 1875.

Rev. WILLIAM GASKELL, M.A., Vice-President, in the Chair.

Mr. John Boyd, of Victoria Park, and Mr. E. W. Nix, M.A., of the Branch Bank of England, were elected Ordinary Members of the Society.

Ordinary Meeting, November 16th, 1875.

Rev. WILLIAM GASKELL, M.A., Vice-President, in the Chair.

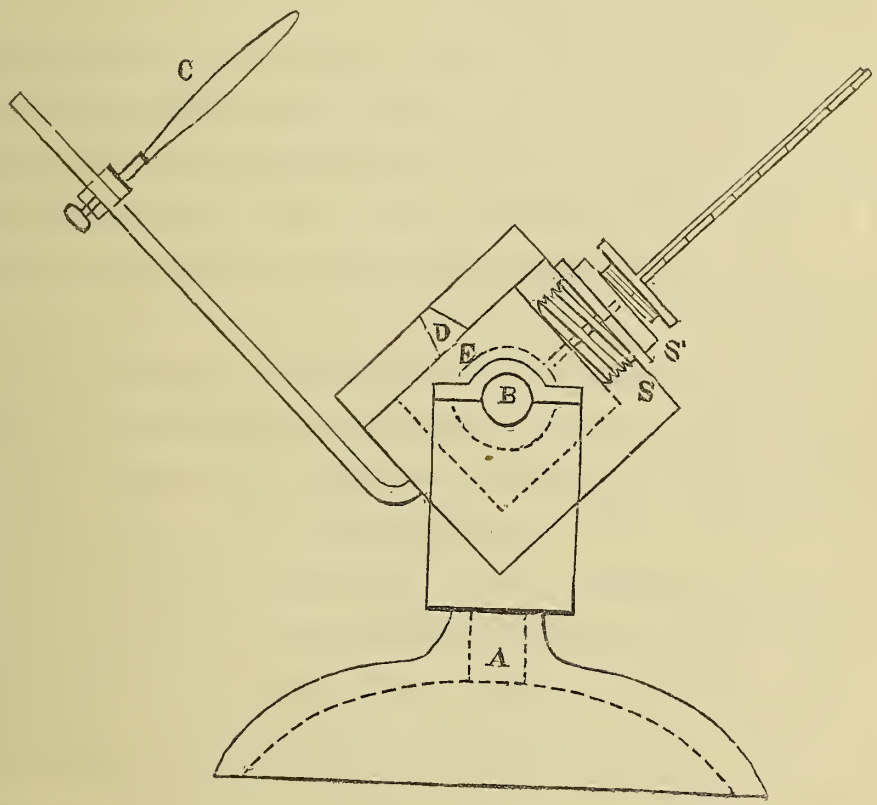
"On an Instrument for Measuring the Direct Heat of the Sun," by Professor BALFOUR STEWART, LL.D., F.R.S.

The instrument generally employed for giving the radiant energy of the sun's rays acts upon the following principle. *In the first place* the instrument is sheltered from the sun but exposed to the clear sky, say for five minutes. Let the heat so lost be termed r. *Secondly*, the instrument is turned to the sun for five minutes. Let the heat so gained be termed R. *Thirdly*, the instrument being now hotter than it was in the first operation is turned once more so as to be exposed to the clear sky for five minutes while it is shielded from the sun. Let the heat so lost be termed r'.

It thus appears that r denotes the heat lost by convection and radiation united when the instrument, before being heated by the sun, is exposed for five minutes to the clear sky, while r' denotes the heat lost by these same two operations by a similar exposure after the instrument has been heated by the sun; and it is assumed that the heat lost from these two causes during the time when the instrument is being heated by the sun will be a mean between r and r', and hence that the whole effect of the sun's rays will be in reality $\mathrm{R}+\frac{r+r'}{2}$.

Now although this assumption may in the average of a great number of experiments represent the truth, yet in many individual cases it may be far from being true. It would therefore seem to be desirable to get rid of this uncertainty by constructing an instrument in which we are sure that the causes of variability are not allowed to operate.

These causes of variability I have attempted to get rid of in the following manner. With the help of Mr. Jordan, mechanician at Owens College, the following instrument has been constructed. It consists of a large mercurial thermometer with its bulb in the middle of a cubical cast iron chamber, this chamber being of such massive material that its temperature will remain sensibly constant for some time.



The chamber with its thermometer has a motion in azimuth round a vertical axis A, and also a motion in altitude round a horizontal axis B. A three inch lens C of 12 inches focal length is attached by means of a rod to the cubical chamber so as to move with it. The nature of this attachment will be seen in the figure. Thus the whole instrument may be easily moved into such a position that the lens as well as the upper side of the chamber which is parallel to the plane of the lens may face the sun, and an image of the sun be thrown through a hole D in the side of the chamber upon the thermometer bulb E.

The stem of the thermometer protrudes from the chamber as in the figure. A screw S somewhat larger in diameter than the bulb of the thermometer is made use of to attach the thermometer to its enclosure, and a smaller screw S′ pressing home upon india rubber washers enables the thermometer to be properly adjusted and kept tight when in adjustment.

In the present instrument the internal diameter of the chamber is 2 inches, while the bulb of the thermometer is about $1\frac{1}{4}$ inches in diameter.

The scale of the thermometer is very open, more than an inch going to one degree. I have generally allowed the image of the sun given by the lens to heat the thermometer bulb for one minute, during which time an increase of temperature, not exceeding in any case two degrees, has been produced.

As far as principle is concerned there appears to be no objection to the present instrument, nevertheless it is open to a very serious practical objection. The scale being so very open, the stem comprehends only a few degrees; frequently, therefore, the temperature is such that the extremity of the mercurial column is either below or above the stem. Now the thermometer has a small upper chamber, and by means of a method of manipulation well known to those who work with thermometers, it is possible to add to or take away from the main body of mercury in the bulb so as to keep the end of the mercurial column always in the stem. But experience has convinced me that for a thermometer with such a large bulb, frequent manipulation of this kind is not unattended with danger to the bulb. On this account the instrument in its present form is, I conceive, unsuited for steady work in an observatory from year to year.

It is however possible without any appreciable sacrifice of the scientific principle of the instrument to alter it in

such a manner as to remedy this defect. Without altering the size of the bulb, I should propose for a permanent instrument a stem say 18 inches long with a bore of such diameter that the stem should embrace a range of temperature betwen 20° Fahr. and 92° Fahr. Thus somewhat less than five degrees will go to the inch. The stem might be protected from the risk of accident by an appropriate shield. Let such a thermometer be heated for two minutes and the size of the lens be somewhat increased. In this case a rise of something like 5° Fahr. will be obtained, and this heating effect might very easily be estimated to one hundredth of the whole, while the same thermometer would serve for all the temperatures likely to occur in these islands during the course of the year.

I ought to add that a pasteboard cover, gilded on the outside is made to surround the chamber, and also that between the lens and the chamber there is a pasteboard shield with a hole in it to permit the full rays from the lens to pass—the object of this shield being to prevent rays from the sun or sky from reaching the instrument.

In such an instrument r or the change taking place in the thermometer before exposure to the sun will in all probability completely disappear, while r' will be extremely small. At any rate we may be quite certain that $R+\frac{r+r'}{2}$ will accurately represent the heating effect of the sun.

We may probably suppose that in the same instrument the lens (which must always be kept clean) will always stop the same or nearly the same proportion of the solar rays. But the lens of one instrument may not stop the same proportion as that of another instrument. This, however, is no objection if it be borne in mind that the instrument is a differential one. In practice there would be some standard instrument which would be retained at a central observatory, and all other instruments would, before being issued, be

compared with it. It would be thus possible to compare together the indications of various instruments working in different places provided that these before being issued had their co-efficients determined at the central observatory.

"On a Colorimetric Method for determining small quantities of Copper," by THOMAS CARNELLEY, B.Sc., F.C.S., Demonstrator in the Chemical Laboratory of Owens College. Communicated by Professor H. E. ROSCOE, F.R.S., &c., &c.

Last year I brought before this Society a paper (Proceedings Vol. XIV., 2) on a colorimetric method for determining iron in waters, and as this method has been found convenient for estimating small quantities of iron in substances other than water,* I thought it would likewise be useful to have a delicate and easy method of a similar kind for copper, and it is the description of such a method that forms the subject of the present paper.

The reagent used is the same as in the case of iron, viz., potassium ferrocyanide, which gives a purple-brown colour with very dilute solutions of copper. This reaction, however, is not so delicate as it is with iron, for 1 part of the latter in 13,000,000 parts of water can be detected by means of potassium ferrocyanide, while 1 part of copper in a neutral solution, containing ammonium nitrate, can be easily detected in only 2,500,000 parts of water. Of the coloured reactions which copper gives with different reagents, those with sulphuretted hydrogen and potassium ferrocyanide are by far the most delicate, and as a preliminary the comparitive values of these two reagents were tested with the following results, the determination being made in each case in 150cc. of water :—

(1) *With* H_2S. 1 part of copper produces a colour in 2,500,000 parts of water.

* Among others I may mention that use has been made of this method by Wanklyn, in the indirect determination of Alum in Bread.—*Chemical News*, Vol. XXXI., p. 67.

(2) *With* K_4FeCy_6

(*a*) In acid solutions, the colour produced being earthy brown, 1 part of copper produces a colour in 1,000,000 parts of water.

(*b*) In neutral solutions, the colour being purple-brown, 1 part of copper produces a colour in 1,500,000 parts of water.

(*c*) In neutral solutions containing ammonium nitrate, the colour being purple-brown, 1 part of copper produces a colour in 2,500,000 parts of water.

From the above it will be seen that of the two reagents, sulphuretted hydrogen is the more delicate, except in the latter case when they are of equal value. But potassium ferrocyanide has a decided advantage over sulphuretted hydrogen in the fact that lead, when not present in too large quantity does not interfere with the depth of colour obtained, whereas to sulphuretted hydrogen it is, as is well known, very sensitive.

And though iron if present would, without special precaution being taken, prevent the determination of copper by means of potassium ferrocyanide, yet by the method as described below the amounts of these metals contained together in a solution can be estimated by this reagent.

As the above results show ammonium nitrate renders the reaction much more delicate; other salts, as ammonium chloride and potassium nitrate, have likewise the same effect.

The method of analysis consists in the comparison of the purple-brown colours produced by adding to a solution of potassium ferrocyanide—first, a solution of copper of known strength, and secondly, the solution in which the copper is to be determined.

The solutions and materials required are as follows :—

(1) *Standard copper solution.*—Prepared by dissolving 0·393 grm. of pure $CuSo_4 \cdot 5H_2O$ in one litre of water. 1cc. is then equivalent to 0·1 mgrm. Cu.

(2) *Solution of ammonium nitrate.*—Made by dissolving 100 grm. of the salt in one litre of water,

(3) *Potassium ferrocyanide solution.*—Containing 1 part of the salt in 25 parts of water.

(4) *Two glass cylinders* holding rather more than 150cc. each, the point equivalent to that volume being marked on the glass. They must, of course, both be of the same tint and as nearly colourless as possible.

(5) *A burette,* marked to $\frac{1}{10}$cc., for the copper solution; a 5cc. pipette for the ammonium nitrate, and a small tube to deliver the potassium ferrocyanide in drops.

The following is the method of analysis:—Five drops of the potassium ferrocyanide are placed in each cylinder, and then a measured quantity of the neutral solution in which the copper is to be determined into one of them (A), and both filled up to the mark with distilled water, 5cc. of the ammonium nitrate solution added to each and then the standard copper solution run gradually into (B), till the colours in both cylinders are of the same depth, the liquid being well stirred after each addition. The number of cubic centimetres used are then read off. Each cubic centimetre corresponds to 0·1 mgrm. of copper, from which the amount of copper in the solution in question can be calculated.

The solution in which the copper is to be estimated must be neutral, for if it contains free acid the latter lessens the depth of colour and changes it from a purple brown to an earthy brown. If it should be acid it is rendered slightly alkaline with ammonia, and the excess of the latter got rid of by boiling. The solution must not be alkaline, as the brown coloration is soluble in ammonia and decomposed by potash; if it is alkaline from ammonia this is remedied as before by boiling it off; while free potash, should it be present, is neutralized by an acid and the latter by ammonia.

Within moderate limits the amount of potassium ferrocyanide does not affect the accuracy of the method as was proved by several experiments, for instance, when $\frac{1}{4}$cc. and 2cc. of the ferrocyanide were added to the two cylinders respectively, water up to the mark, and 5cc. of ammonium nitrate to each, then 7cc. of the standard copper solution produced in each an equal depth in colour.

The same may be said of the ammonium nitrate, for in one of several trials, all leading to the same result, when there were five drops of ferrocyanide in each cylinder, with water up to the mark, and 5cc. of ammonium nitrate in one and 15cc. in the other, an equal depth of colour was obtained on running into each 7cc. of the standard copper solution.

The following are the results obtained by estimating the copper in pure solutions of copper sulphate of known strength :—

Copper found.		Copper calculated.	
205·00	mgrm.....	202·08	mgrm.
32·36	„	31·32	„
6·50	„	6·27	„
1·18	„	1·13	„
1·13	„	1·21	„
0·96	„	1·01	„
0·75	„	0·75	„
0·59	„	0·61	„
0·52	„	0·50	„
0·42	„	0·40	„
0·39	„	0·38	„
0·22	„	0·20	„
0·13	„	0·13	„
0·12	„	0·10	„
0·055	„	0·050	„

In order to test the effect which the different salts might have on the accuracy of the method, 8·0 grms. of a mixture of the following salts, viz.:—Ammonium chloride, sodium chloride, potassium nitrate, calcium chloride, calcium sulphate,

and magnesium sulphate, were dissolved with an amount of copper sulphate, containing 0·101 grm. Cu. to 1 litre. Varying quantities of this solution were taken, and the copper estimated therein with the following results, from which it is seen that these salts have no detrimental effect. :—

Copper found.	Copper calculated.
0·54 mgrm.....	0·51 mgrm.
0·71 „	0·71 „
0·91 „	0·91 „

In the same manner the effect of the presence of colourless non-volatile organic matter was tested by dissolving up 13 grms. of sugar with an amount of copper sulphate equivalent to 0·0505 grm. copper in 1 litre of water, and the copper estimated in two different portions as before, the following numbers being obtained :—

Copper found.	Copper calculated.
0·52 mgrm.....	0·51 mgrm.
0·82 „	0·81 „

In order to see what influence the presence of lead might exercise on this method of estimating copper, a quantity of the sulphate containing 0·255 grm. Cu. was dissolved in water, the copper precipitated by potash, washed, and the oxide dissolved in nitric acid and the solution after nearly neutralizing with ammonia diluted to 1 litre with the addition of 2 grm. of lead nitrate = 1·25 grm. Pb. Varying quantities of this solution were taken, and the copper in them estimated with the following results :—

Copper found.	Copper calculated.
0·80 mgrm.....	0·77 mgrm.
0·75 „	0·70 „
0·51 „	0·49 „
0·49 „	0·51 „
0·38 „	0·35 „

From which it will be seen that lead when present in not too large quantity has little or no effect on the accuracy of the method. The precipitate obtained on adding potassium

ferrocyanide to a lead salt is white, and this, except when present in comparatively large quantity with respect to the copper, does not interfere with the comparison of the colours. In the above experiments the proportion of lead to copper was as 5 to 1.

When copper is to be estimated in a solution containing iron the following is the method of procedure to be adopted. To the solution a few drops of nitric acid are added in order to oxidise the iron, the liquid evaporated to a small bulk and the iron precipitated by ammonia. Even when very small quantities of iron are present this can be done easily and completely if there is only a very small quantity of fluid. The precipitate of ferricoxide is then filtered off, washed once, dissolved in nitric acid and reprecipitated by ammonia, filtered, and washed. The iron precipitate is now free from copper, and in it the iron can be estimated by dissolving in nitric acid, making the solution nearly neutral with ammonia and determining the iron by the method given in the paper before referred to. The filtrate from the iron precipitate is boiled till all the ammonia is completely driven off, and the copper estimated in the solution so obtained as already described. The following are the results obtained with solutions containing known quantities of iron and copper: —

	Copper		Iron	
	Found	Calculated	Found	Calculated
(1)	0·53 mgrm.	0·51 mgrm.	0·22	0·20 mgrm.
(2)	0·69 „	0·61 „	2·15	2·40 „
(3)	0·79 „	0·76 „	2·42	3·00 „
(4)	0·66 „	0·66	——	——

When the solution containing copper is too dilute to give any coloration directly with potassium ferrocyanide, a measured quantity of it must be evaporated to a small bulk and filtered if necessary, and if it contains iron, also treated as already described.

In the determination of copper and iron in water, for which the method is specially applicable, a measured quantity is evaporated with a few drops of nitric acid to dryness, ignited to get rid of any organic matter that might colour the liquid, and dissolved in a little boiling water and a drop or two of nitric acid, if it is not all soluble it does not matter; ammonia is next added to precipitate the iron, the latter filtered off, washed, redissolved in nitric acid, and again precipitated by ammonia, filtered off and washed. The filtrate is added to the one previously obtained, and the iron estimated in the precipitate and the copper in the united filtrate.

The distilled water used in the Owens College Laboratory, and which is condensed by the apparatus made by Hirzel, of Leipzig, gave, on analysis by the above method, the following results, two litres of the water being used for the purpose :—

0·15 parts Cu.
0·03 parts Fe. } in 1,000,000 parts of water.

The copper and iron in this case were evidently derived from the fittings of the condensing apparatus, which consisted in great part of these metals.

Ordinary Meeting, November 30th, 1875.

EDWARD SCHUNCK, Ph.D., F.R.S., &c., President, in the Chair.

"On the Estimation of very small quantities of Lead and Copper," by M. M. PATTISON MUIR, F.R.S.E., Assistant Lecturer on Chemistry, Owens College.

As I have lately been occupied with experiments upon the action of saline solutions upon lead and copper, which involved the measurement of very small quantities of these metals I thought it might be well to test the accuracy and delicacy of the method employed.

The method itself is in no way new, being that described by Wanklyn in his Book on "Water Analysis." The depth of colour produced by the addition of sulphuretted hydrogen water to a known volume of the liquid under examination is compared with the colour produced, by the same means, in an equal volume of water to which a known amount of lead or copper, in solution, has been added. In comparing the colour of the liquid under examination with the standard liquid I find it preferable to employ stout glass tubes, holding about 100 cc. and having a diameter of about 1·5 cm., rather than white porcelain dishes as recommended by Wanklyn. The contents of the tubes are thoroughly mixed by means of glass tubes on the ends of which bulbs have been blown. (See *Thorpe on a method of estimating nitric acid, &c.* Chem. Soc. J. [2] XI. 547.)

Wanklyn recommends the use of standard solutions, 1 cc. of which is equal to 1 mgm. of copper or of lead: he employs 70 cc. of the water to be tested. If, therefore, the colour produced on adding sulphuretted hydrogen water to 70 cc. of the liquid under examination is found to be equal

to that produced by the addition of the same reagent to 70 cc. of distilled water to which 1 cc. of the standard has been added, we shall have 1 grain per gallon of lead in the water. But one-tenth of a grain of lead per gallon is generally considered hurtful when present in a drinking water; to estimate this we should require to use only 0·1 cc. of the standard: a very small error in reading the burette measurements would introduce a comparatively large error in the result. Thus in the case of a water containing one-tenth grain of lead per gallon an error in reading of 0·05 cc. would introduce an error in the quantity of lead equal to one-half of the total quantity to be estimated. The first point, therefore, to investigate appeared to be *the strength of the standard solutions.* I shall describe the experiments made with copper.

Standard used 1 cc. = 1 mgm. copper.

Expt.	Taken.	Found.
No. 1.....	5 mgm. per litre...	4 mgm. per litre.
No. 2.....	2·5 „ „	2 „ „

Standard used 1 cc.=0·1 mgm. copper.

	Taken.	Found.
No. 3.....	5 mgm. per litre...	4·8 mgm. per litre.
No. 4.....	2·5 „ „	2·4 „ „
No. 5.....	0·5 „ „	0·5 „ „

In each case 50 cc. of liquid was used.

Similar results were obtained with lead solutions.

The use of a standard, 1 *cc. of which is equal to* 0·1 *mgm.*, of copper or of lead enables more accurate and more delicate results to be obtained than the use of a stronger standard does.

The second point to be determined was *the limits of accuracy of the method,* and first as to the lower limit.

From the experiments with copper already detailed it will be seen that 0·5 mgm. of copper per litre could be estimated by using 50 cc. of the liquid.

Standard used 1 cc. = 0·1 mgm. copper.

Solution contained 0·25 mgm. of copper per litre. Details as before.

Added 0·3 cc. standard. Colour too dark.
Added 0·2 cc. ,, Colour rather too dark.
Added 0·1 cc. ,, Colour equal to the other.

	Taken.	Found.
No. 6	0·25 mgm. per litre.	0·20 mgm. per litre.

In this experiment it was very difficult to determine the exact point at which the colours were the same, as the intensity of coloration produced was very slight. A further addition of 0·05cc. of the standard could hardly be said to produce a noticeable change in the depth of colour.

I think, therefore, that 0·5 mgm. of copper per litre = 0·035 grains per gallon is the smallest quantity which can be accurately estimated by this process when working with 50 cc. of the liquid under examination.

The amount of lead which can be estimated with accuracy is less minute than the amount of copper.

Standard used 1cc. = 0·1 mgm. lead.

	Taken.	Found.
No. 7	0·25 mgm. per litre	no coloration.
No. 8	0·5 ,, ,,	0·4 mgm. per litre.
No. 9	0·75 ,, ,,	0·6 ,, ,,
No. 10	1·0 ,, ,,	1·0 ,, ,,

1 mgm. of lead per litre = 0·07 grains per gallon, is, therefore, the smallest quantity which can be accurately estimated by this process when working with 50cc. of the liquid under examination.

By the evaporation of 1 litre of water to 50cc., a quantity of copper so small as 0·025 mgm. per litre, or of lead equal to 0·05 mgm. per litre, can be estimated by this process. In other words, the process will estimate 1 part of copper in 2,000,000 parts of water, or 1 part of lead in 1,000,000 parts of water.

Secondly, as to the upper limit.

Standard used 1cc. = 0·1 mgm. copper.

	Taken.	Found.
No. 11.....	20 mgm. per litre...	20·4 mgm. per litre.
No. 12.....	10 „ „	10 „ „
No. 13.....	25 „ „	24—28 „ „
No. 14.....	30 „ „	28—32 „ „

20 mgm. of copper per litre = 1·4 grains per gallon is the largest quantity which can be estimated by this method when working with 50cc. of the liquid under examination.

With lead the following results were obtained :—

	Taken.	Found.
No. 15.....	10 mgm. per litre...	10 mgm. per litre.
No. 16.....	12 „ „	12—15 mgm. per litre.
No. 17.....	15 „ „	colour too dark to allow of estimation.

10 mgm. of lead = 0·7 grains per gallon, is, therefore, the largest quantity which can be estimated by this method when working with 50cc. of liquid.

In making these determinations, I found that the colours of the liquids might be compared *immediately* after the addition of sulphuretted hydrogen. The colours did not become intensified on standing.

I also found that it was immaterial whether the standard was added before the sulphuretted hydrogen water or *vice versa*. Thus there is no need if the colour of the standard be too light, to prepare a fresh standard, as must be done in nesslerising. It is only necessary to add another measured quantity to the liquid which already contains sulphuretted hydrogen.

The addition of one or two drops of dilute hydrochloric or nitric acid in no way affected the accuracy or delicacy of the estimation of copper. In the case of lead, a drop of hydrochlorie acid caused a faint turbidity (especially in estimating large quanities of the metal), which interfered materially with the results. If an acid must be added, acetic acid is, I think, the best.

When working with 50cc. of liquid, so small a quantity as 0·5 mgm. of copper, or 1 mgm. of lead per litre, may be estimated by this process. If it is required to estimate smaller quantities than these, the liquid must be concentrated by evaporation. If the amount of copper exceed 20 mgm., or of lead exceed 10 mgm. per litre, a smaller quantity of the liquid than 50cc. must be used.

"On Certain Circumstances which affect the Purity of Water supplied for Domestic Purposes," by M. M. Pattison Muir, F.R.S.E., Assistant Lecturer on Chemistry, Owens College.

Water as supplied for domestic use may suffer contamination from various sources. Those which I propose to consider are (1) the metallic pipes through which the water flows, and the metallic vessels in which it may be stored, (2) certain of the metallic vessels through which the water may pass during various domestic processes, and (3) the existence of cisterns inside the house in which the water may be stored before it is used.

The metals which are most commonly employed in the formation of water pipes, or of vessels in which water is kept, are lead and copper: these metals exert, as is well known, a poisonous action upon the human organism.

It is known that water exerts a certain solvent action upon these metals, and that this action varies in accordance with the quality and quantity of the salts held in solution by the water. I have endeavoured to obtain a few definite measurements of this action in regard to (*a*) the nature of the salts in solution, (*b*) the quantity of those salts, and (*c*) the length of time during which the action proceeds.

I. *Action on Lead.*

A number of solutions were made containing a known amount of various salts dissolved in distilled water: pieces of clean bright lead were suspended in these liquids for

various lengths of time, and the amount of lead which was dissolved was estimated at certain intervals; the method employed being the colorimetric one described in the foregoing paper. The salts employed, the amounts of each, and the amount of lead dissolved after 24, 48, and 72 hours' action are stated in the following table in mgrms. per litre and in grains per gallon. The surface of lead exposed measured 5600 sq. mm.

TABLE A.

Lead dissolved by water containing various salts in solution.

Salt.	Mgms. per litre.	Grains per gall.	Lead dissolved. In Mgms. per Litre. After 24	48	72	In Grains per Gallon. 24	48	72 hrs.
Ammonium Nitrate	20	1·4	13·0	...	25·0	0·91	...	1·75
Ditto	40	2·8	15·0	15·0	32·0	1·05	1·05	2·24
Ditto	80	5·6	15·0	...	...	1·05	...	...
Potassium Nitrate and Sodium Sulphate ...	20 and 50	1·4 and 3·5	2·0	2·0	...	0·14	0·14	...
Potassium Nitrate and Sodium Sulphate ...	40 and 212	2·8 and 14·7	0·8	1·0	1·2	0·05	0·07	0·08
Potassium Nitrate and Potass. Carbonate...	45 and 305	3·1 and 21·5	...	...	0·3	...	...	0·021
Potassium Nitrate and Potassium Sulphate	70 and 504	5·4 and 35·2	...	...	0·5	...	...	0·035
Calcium Sulphate...	252	17·5	0·4	...	0·8	0·02	...	0·05
Ditto	408	28·5	0·4	...	1·0	0·02	...	0·07
Potass. Carbonate ..	310	21·7	...	...	0·2	...	...	0·014
Ditto	516	36·1	...	...	0·2	...	...	0·014
Calcium Chloride ...	250	17·5	0·5	0·5	0·5	0·04	0·04	0·04
Ditto	510	35·7	0·3	...	0·4	0·02	...	0.028
Sodium Sulphate ...	200	14·0	...	...	0·8	...	...	0·05
Ditto	400	28·0	...	...	0·5	...	...	0·03
Ammonium Nitrate and Calcium Chloride ...	20 and 60	1·4 and 4·2	...	...	1·8	...	...	0·126
Ammonium Nitrate Potass. Carbonate and Sodium Sulphate ...	20 100 and 200	1·4 7·0 and 14·0	...	...	0·4	...	...	0·028
Sodium Sulphate Potass. Carbonate and Calcium Chloride ...	200 40 and 100	14·0 2·8 and 7·0	...	...	0·1	...	...	0·007
Loch Katrine water			1·0	1·0	1·5	0·07	0·07	0·105
Distilled water			2·0	2·0	3·0	0·15	0·15	0·210

From this table it is evident that the salts enumerated

have, when in solution, very different actions upon lead. Nitrates undoubtedly very largely increase the solvent action of water upon lead : the other salts generally diminish this action.

The general conclusion which I would draw from these results are :—

(1.) *Nitrates* if present alone even in small quantity cause water to exert a very marked solvent action upon lead.

(2.) The presence of other salts—*sulphates, carbonates,* and *chlorides—along with nitrates,* greatly decreases, or even stops, this solvent action : carbonates especially exercise a deterrent action.

(3.) *Carbonates, sulphates,* and *chlorides,* when added to distilled water, greatly diminish the solvent action of that water upon lead.

(4.) A small quantity—about 15 grains per gallon—of these last mentioned salts exercises almost as great a deterrent action as a comparatively large quantity, about 35 grains per gallon.

(5.) The amount of lead dissolved increases but slightly after the lapse of twenty-four hours, in the presence of these salts which exercise a deterrent action upon the solvent power of water on lead. In the presence of salts which increase this action—notably of nitrates—the amount of lead dissolved increases with the length of time during which the water remains in contact with the lead. I cannot speak with certainty upon this point for a greater length of time than 72 hours.

In these experiments the lead was uniformly clean and bright. Inasmuch as natural waters, even if contaminated with nitrates, usually contain small quantities of soluble carbonates, sulphates, or chlorides, the solvent action of these waters upon leaden pipes and leaden cisterns may, I think, be said to be, under ordinary circumstances, exceedingly small. I would especially draw attention to the experiment

made with water containing 1·4 grains of ammonium nitrate and 42 grains of calcium chloride per gallon; the amount of lead dissolved, after 72 hours being only 0·126 grains per gallon, whereas water containing the same amount of ammonium nitrate, but without the addition of any other salt, dissolved 1·75 grains per gallon, or about fifteen times as much lead in the same time. As a water which contains nitrates very often also contains chlorides this reaction is one of some importance.

Under certain circumstances there can be no doubt that water will dissolve considerable quantities of lead, this is especially the case with water charged with carbon dioxide, and with hot water

Dr. Roscoe has described a case in which a leaden cistern was very quickly acted upon by hot water.*

For the following details regarding the amounts of lead found in various samples of aerated beverages in the manufacture of which leaden apparatus had been employed, I am indebted to my friend, Dr. Milne, of Glasgow.

TABLE B.

Lead found in various samples of aerated beverages.

Description of Liquid.	Quantity of Lead in grains per gallon.
Lemonade	0·20
Do.	0·40
Do.	0·05
Gingerade	0·10
Sodawater	0·60
Do.	0·05

In addition to these numbers I have determined the following, which show the amounts of lead dissolved by distilled water charged with carbon dioxide at the ordinary atmospheric pressure for varying lengths of time, and also the amounts dissolved by the same water on the addition of various salts. The surface of lead exposed measured 2,100 square millimetres.

* Proc. Lit. and Phil. Soc., of Manchester, Vol. xiv., p. 23.

Table C.

Lead dissolved by water charged with carbon dioxide at ordinary pressure.

	Mgms. per litre.	Grains per gallon	Lead Dissolved. In mgms. per litre. After 24	48	72	In grains per gallon. 24	48	72 hrs.
Distilled water charged with Carbon Dioxide			3	3	3	0·21	0.21	0·21
The water poured off, more added and again poured off, and finally fresh water containing Carbon Dioxide added ...			None.			None.		
Potassium Carbonate and Ammonium Nitrate	100 and 20	7·0 and 1·4	Merest trace.			Merest trace.		

As the results indicated that water charged with carbon dioxide at the ordinary atmospheric pressure exercises no considerable solvent action upon lead, and moreover that this action ceases on the addition of carbonates; the large amounts of lead found in some of the samples of sodawater examined by Dr. Milne are probably due to the increased solvent action of water containing large quantities of carbon dioxide forced into it under pressure. In order to test the truth of this supposition I have made a few determinations of the amounts of lead dissolved by distilled water, and by the same water containing known quantities of various salts when charged with carbon dioxide at a pressure of several atmospheres.

The apparatus consisted of an ordinary *gasogene* used for making so-called "soda water." From the known capacity of the globe and the weight of sodium carbonate and tartaric acid employed the pressure exerted in the interior of the vessel by the carbon dioxide was calculated as approximately equal to 6 atmospheres.

The surface of lead exposed measured 750 sq. mm.

TABLE D.

Lead dissolved by water charged with carbon dioxide at a pressure of about 6 atmospheres.

Salt.	Mgms. per litre.	Grains per gallon.	Lead Dissolved.			
			In Mgms. per litre.		In Grains per gallon.	
			24 hours.	48 hours.	24 hours.	48 hours.
Potassium Carbonate..	80	5·60	13·2	32·0	0·924	2·24
Ditto.....	160	11·20	...	6·0	.....	0·42
Calcium Chloride	160	11·20	32	44	2·24	3·08
Ammonium Nitrate ...	16	1·12	5	...	0·35	.....
Ditto.....	40	2·80	10	35	0·70	2·45
Distilled Water	...	...	14·8	24	1·036	1·68

It appears from these numbers that distilled water charged with carbon dioxide under a pressure of (approximately) 6 atmospheres dissolves five times as much lead as the same water charged with the gas at the ordinary atmospheric pressure: that the presence of a small quantity of ammonium nitrate does not increase the solvent action until after a lapse of 48 hours or so: and that potassium carbonate, when present in somewhat large quantities, exerts a marked deterrent action. The amount of lead dissolved, however, even in the presence of potassium carbonate, is far too large to allow of such a water being drunk with safety.

II. *Action on Copper.*

The experiments under this heading were carried out in a manner similar to that already described. The pieces of copper foil presented a surface of 420 sq. mm. to the action of the various solutions. The results obtained were with one exception negative: no copper was dissolved. The action of the following liquids was examined: — *distilled water*; the same containing *ammonium nitrate* in quantities varying from ·02 grams per litre (=1·4 grains per gallon) to ·408 grams per litre (=28·56 grains per gallon); the same containing *potassium nitrate* in like amounts; the same containing *ammonium sulphate* in quantities varying from ·10 to ·20 grams per litre (=7 to 14 grains per gallon): and also distilled water containing simultaneously *carbonates and nitrates, carbonates and sulphates,* and *chlorides and*

nitrates. The length of time during which the copper was exposed to the action of these solutions varied from 18 to 150 hours. The only liquid which exercised *any* solvent action upon the copper was that containing the large quantity of *28·56 grains per gallon of ammonium nitrate*; this action was manifested only after *150 hours'* contact of the liquid with the copper, the amount of metal which had then passed into solution being equal to *3 milligrams per litre,* or *0·21 grains per gallon.*

The general conclusion to be drawn from these experiments therefore undoubtedly is, that at ordinary temperature neither distilled water nor water containing the salts which commonly occur in drinking waters exercises a solvent action upon copper.

That water charged with carbon dioxide will dissolve copper is apparent from the following figures, which represent the amounts of that metal found by Dr. Milne in various samples of aerated beverages.

TABLE E.

Copper found in various aerated beverages.

Description of liquid.	Quantity of copper in grains per gallon.
Soda water	·084
Potash water	·098
Lemonade	·053
Ginger ale	·053
Potash water	·100
Aerated water	·089
Soda water	·100
Aerated water	·084
Soda water	·036

In order to arrive at some accurate measurements of this solvent action of water containing carbon dioxide upon copper, I prepared a number of solutions charged with that gas at the ordinary atmospheric pressure and placed in each a piece of clean copper foil exposing a surface of 2100 sq. mm. The amount of copper dissolved was estimated by adding

sulphuretted hydrogen and comparing the depth of colour produced with that in a standard liquid: the process is exceedingly accurate and delicate.

TABLE F.

Copper dissolved by water charged with Carbon dioxide at ordinary pressure.

Salt.	Mgms. per Litre.	Grains per Gallon.	Copper dissolved.							
			Mgms. per Litre.				Grains per Gallon.			
			24	48	72	120	24	48	72	120 hrs.
Potassium Carbonate..	200	14	0·1	...	0·15	0·2	·007	...	·0105	·014
Calcium Chloride	200	14	0·7	...	1·20	1·80	·049	...	·084	·126
Ammonium Nitrate ...	20	1·4	0·3	...	0·60	1·40	·021	...	·042	·098
Ditto.....	40	2·8	0·6	...	0·80	1·40	·042	...	·056	·098
Potassium Carbonate and Ammonium Nitrate ...	100 and 20	7 and 1·4	0·2	...	0·30	1·0	·014	...	·021	·07
Potassium Carbonate and Ammonium Nitrate ...	200 and 40	14 and 2·8	trace	...	trace	0·1	trace	...	trace	·007
Ammonium Nitrate and Calcium Chloride	20 and 200	1·4 and 14	0·6	...	2·4	3·6	·042	...	·168	·252
Distilled Water			0·1	0·3	...	1·0	·007	·021	...	·07

The general conclusions which I would draw from these results are:

(1) Distilled water, charged with carbon dioxide, exercises a notable solvent action upon copper, the amount of metal dissolved increasing with the length of time during which it is exposed to the action of the water.

(2) The salts which have the greatest effect in increasing this action are *chlorides* and *nitrates*, especially the latter: if there are *both* present the action is very largely accelerated.

(3) *Carbonates*, especially when present in large quantities, very materially diminish this solvent action.

(4) If *carbonates and nitrates* are *present together* the solvent action of the latter is much diminished by the presence of the former salts, so much so indeed that if the carbonates be present in proportionately large quantities the solvent action upon the copper almost entirely disappears.

I have also carried out a few experiments with the view

of determining the amounts of copper which are dissolved by water charged with carbon dioxide under a pressure of several atmospheres: the results are subjoined.

The apparatus were the same as that employed in the experiments with lead.

Surface of copper exposed=2100 sq. mm.

TABLE G.

Copper dissolved by water charged with carbon dioxide at a pressure of about 6 atmospheres.

Salt.	Mgms. per Litre.	Grains per Gallon.	Copper dissolved.			
			Mgms. per Litre		Grains per Gall.	
			24 hrs.	48 hrs.	24 hrs.	48 hrs.
Potassium Carbonate ...	40	2·8	1·0	1·2	0·7	·084
Ammonium Nitrate.....	16	1·12	...	0·8	...	·056
Ditto	80	5·60	1·2	1·4	·084	·098
Distilled Water.....	...	...	0·4	0·6	·028	·042

Distilled water, charged with carbon dioxide, under a pressure of (approximately) 6 atmospheres, dissolves about three times as much copper as the same water charged at the ordinary atmospheric pressure. Nitrates increase this action and carbonates diminish it.

III. *Influence of house cisterns upon the water supply.*

There appears to be a somewhat wide-spread feeling against the use of cisterns in dwelling-houses, which is, I suppose, chiefly due to the fact that the waste pipe from the cistern is generally in connection with the soil pipe which carries off the drainage of the house.

The hurtful sewer gases may thus readily find their way into the cistern, and so contaminate the water therein stored. On the other hand, however, it may be urged that inasmuch as the water in cisterns is frequently changed there is no great probability that the water actually used for domestic purposes will be, at any rate largely, contaminated by sewer gas. I have attempted to obtain some definite measurements of the amount of contamination

present in cistern waters, in so far as this may be estimated by the chemical processes at present in our possession.

The method which I have adopted consists in measuring the amount of free and of albumenoid ammonia, and the amount of nitrogen existing as nitrates and nitrites: from these data we may deduce, at any rate comparative measurements, of the purity of various waters.

In order to prove conclusively, for my own satisfaction, that if sewer gases be absorbed by water their presence will be indicated by a marked increase in the quantities of ammonia, free and albumenoid, obtained from that water on analysis, I carried out the following preliminary experiment:—

A quantity of distilled water, free from ammonia, was placed in a porcelain basin, which was covered with porous paper, and suspended at a short distance above the liquid in a sewer which received the refuse from a very large area, chiefly occupied by dwelling-houses, in Glasgow. After 96 hours, the free and albumenoid ammonia were estimated with the following results:—

Free ammonia = 0·60 mgms. per litre = parts per million.
Albumenoid „ = 0·54 „ „ = „ „

It is thus evident that the absorption of sewer gases by water causes a marked increase in the quantities of ammonia obtained on analysis.

The method adopted for the estimation of ammonia was the well known one of Wanklyn and Chapman: the method for the estimation of nitrates was that described by Thorpe in the Journal of the Chemical Society for June, 1873. This method consists in evaporating the water, along with a fragment of ignited quicklime, to a small bulk, and then evolving the nitrogen, as ammonia, by the action of zinc, coated with a deposit of spongy copper, at a boiling heat.

In selecting the waters for examination I endeavoured, as far as possible, to obtain typical samples: in this endeavour

I was greatly aided by the kindness of Mr. Macleod, the Sanitary Inspector for Glasgow, who obtained for me samples of waters from various houses situated in the lower parts of the town.

The results are calculated as follows :—

TABLE H.

Ammonia and nitrates found in various samples of water.

	Mgms. per Litre=Parts per Million.											
	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	xi.	x.	xi.	xii.
Free Ammonia	·005	·085	·023	...	·015	·015	·010	·035	·015	·075	·200	·045
Albumenoid Do. ...	·092	·120	·080	·082	·090	·080	·085	·085	·070	·065	·370	·090
Nitrogen as Nitrates & Nitrites.	·309	·463	...	·321	·360	·20	·258	...	·284	·306	·414	...

These samples were obtained from the following situations. No. 1. *From main pipe.* No. 2. *From cistern in same house, little used.* No. 3. *From cistern in house similar to No. 2, but water generally used.* No. 4. *From pipe leading directly out of the bottom of cistern in well-situated dwelling house.* No. 5. *From cistern in smaller dwelling house.* No. 6. *From small cistern supplying part of a dwelling house only.* No. 7. *From public well supplied by Loch Katrine water contained in a wooden cistern closed at the top.* No. 8. *From cistern situated just under the slates in a house in a lower locality than any of the preceding.* No. 9. *From cistern over water-closet in a dwelling house.* No. 10. *From cistern similar to above.* No. 11. *From the cistern same as No. 9, but after stirring up the muddy deposit at the bottom.* No. 12. *From cistern near the slates in a house where there had been two cases of fever and where the water was complained of.*

Omitting for the present No. 11, it is found that No. 2 sample yields the highest number for free and for albumenoid ammonia, also for nitrates. Now this sample was taken from the cistern of a house in which the pipes have been recently entirely renewed, and in which the pipe leading from the water-closet to the main drain is thoroughly venti-

lated. The water in this cistern is however very rarely used; for all domestic purposes a supply is obtained directly from the main; it would therefore appear that sewer gases are slowly absorbed by water stored in such a cistern. That this absorptive action must take place slowly is evident if we look at the results obtained from the other waters. Although many of these waters were taken from badly situated cisterns, yet in none of them can the influence of sewer gases be distinctly traced. We must therefore conclude that the rapidity with which the water in the cistern has been changed has prevented any appreciable action of the gases upon these waters. There are, it is true, slight variations in the numbers obtained, but in no case do we find a notable increase as compared with water from the main pipe.

The amount of ammonia, &c, obtained from a sample of the slimy matter found at the bottom of one of the cisterns (No. 11) indicates that a great part of the ammonium salts, &c., is concentrated therein; this matter may therefore perhaps exercise a certain beneficial effect upon the water.

The general conclusions which I would draw from these results are :—

(1.) That sewer gases are absorbed by water, but that this absorption takes place slowly.

(2.) That in ordinary house cisterns the water is not contaminated to any great extent with sewer gases, probably because of the short time during which this water is allowed to remain in the cistern, and also perhaps because of the deposition of part of the impurities in the muddy substance which settles at the bottom of the cistern.

The general problem of the influence of the means of supply upon potable waters is a very wide one. I offer these measurements as a contribution towards its solution.

In the course of the discussion which took place after the reading of the above papers several of the members stated that the town's water as received at their houses was sometimes very turbid, and the President said it ought never to be used for drinking purposes without being filtered.

J. G. Lynde, M. Inst. C.E., F.G.S., said that at his house he had always found the water quite clear and pure, and that although he had a filter it was now never used.

T. H. G. Berrey, Ass. Inst. C.E., superintendent of the Manchester Corporation Water Works, stated, in reply, that there was no reason why the water should be discoloured at the points named, except that it must have been caused by the neglect of the turncock to cleanse the hydrants according to instructions. The general supply throughout the 36 townships supplied by the Manchester Corporation was quite satisfactory, and the water was never rendered turbid except in the case of a very heavy thunderstorm, when the turbid water would sometimes, during the night, get into the service reservoirs from the adjoining brooks before it could be sent down the flood watercourse.

MICROSCOPICAL AND NATURAL HISTORY SECTION.

November 8th, 1875.

Alfred Brothers, F.R.A.S., in the Chair.

Mr. Percival exhibited specimens of Bryum Neodamense Itzig [=B. formosum, Wilson MSS.] found by him, in company with Dr. Wood and Mr. T. Rogers, on May 23rd, 1875, fruiting abundantly. Hitherto it had only been found in a barren state in Britain. The locality is near Freshfield, Lancashire.

The true place of this moss is next to B. pseudotriquetrum, common upon the Lancashire mosses.

It was originally found at Birkdale, near Southport, but soon disappeared, owing to draining and building operations; then it was again observed at the Bullrush Slack, by its original discoverers, viz., Dr. Wood, Mr. W. Wilson, and Mr. H. Boswell, but never in a fruiting condition.

Mr. Thos. Rogers exhibited living specimens of the rare Irish Slug, *geomalacus maculosus*, from Lough Corrib, its only known British habitat, and even there its range is exceedingly restricted.

"The Fauna of Cymmeran Bay, Anglesea," by John Plant, F.G.S.—Part 2.

The list of the fishes and mollusca which I read to the Section last April included all the species which had been identified from the collections made in the summer of 1874 and at Easter, 1875.

The present list includes those which have been added by a further examination of the shores and waters along the coast from Rhoscolyn to Aberffraw, of which line Cymmeran Bay forms the centre.

The time devoted to the work extended from the end of July to September, when the weather was rarely disturbed by furious gales, such as prevail on this coast in spring and autumn—so that the new collection possesses none of the varieties which the rude waves of the Atlantic at such times cast upon the rocks and sands.

The species in this list are therefore more likely to be local and permanent than are some included in the former list.

During the summer a fine young seal, *Phoca vitulina*, was caught fast asleep upon the rocks in the bay, and kept in confinement a few days with the intention of sending it to

Belle Vue Gardens, Manchester, but it managed to escape from the room it was kept in, and actually travelled down to the rocks, and got away to sea.

The fishermen say that the seal is well known along the coast, and breeds in the more inaccessible clefts and caverns in the bold sea cliffs, from the North Stack to Rhoscolyn. The Welsh name for The Skerries, the well known rocky islets off Carmels Point, is *Ynysoedd Moelroniaid*, the Isles of Seals. A century back, the seal was very common on these rugged and little frequented coasts.

A few years ago, a shoal of Cetaceans found their way to the head of Cymmeran Bay and were stranded in the strait which divides Holyhead from Anglesea. They proved to be the Bottle-nosed Dolphin, *Tursio truncatus*, of Montagu.

The common Porpoise, *Phocœna communis*, not infrequently is seen and captured when sporting out in the channel.

The additions to the fishes already enumerated, are not many, for it is not easy to obtain specimens of the species that are small and worthless for the table—they readily escape through the nets used for mackerel and herrings.

Specimens of *big sharks* are often seen in the bay by the fishermen, but they give them a wide birth, and I cannot make out the species from the imperfect descriptions given in such an unscientific tongue as is the mixed Welsh and English.

The Picked Dogfish, *Acanthias vulgaris*, will at times get caught in the nets during the night, after making a hearty meal upon the cod and whiting.

The spotted Ray, *Raia maculata*, is often captured by trawling, but it is not used for food, being cut up like its congenor the thornback Ray, as bait for lobsters and crabs.

The Turbot, *Rhombus maximus*, is caught of moderate size.

The Garfish, *Belone vulgaris*, rare.

The Grey Gurnard, *Trigla gurnardus*, is common with the Piper Gurnard all the summer.

The additions to the former list of mollusca made during a long visit have been sixty-two species, making a list of one hundred and forty-one species. It is remarkable that although the sandy shores about Cymmeran and Aberffraw bays are both extensive and level between high and low tidal marks, such well-known common species as *Cardium edule*, *Turritella communis*, *Mytilus edulis*, and others, should be excessively scarce, whilst such species as *Cyprœa Europœa*, *Patella pellucida*, *Tellina fabula*, *T. tenuis*, *Cyprina Islandica*, *Mactra stultorum*, *Pecten maximus*, and Littorinæ should be fairly abundant, if not quite common.

The small species of *Rissoa Odostomia*, *Skenea*, and *Mangelia*, occur in great numbers, the sand in places being almost made up of these shells, mixed with Entomostraca, Serpulæ, comminuted shells, and crustacean claws. The varieties of *Rissoa parva*, *costata* and *striata* are endless, and it would be easy to multiply species of this genus, and also of *Skenea*, if only extremely marked or smooth specimens were regarded.

In my former list are many species which were called rare, as only one or two specimens or even a single valve had been found in 1874, or at Easter of 1875. In some cases this rarity has been proved by not finding additional specimens this summer, as in *Corbula*, *Psammobia*, *Dentalium*, *Turritella* (only two), *Chemnitzia*, *Trophon*, and *Cylichna*.

Amongst the fresh species there are none that occur abundantly, but *Pecten pusio*, *Cyprina*, *Scaphander*, *Ceratisolen*, *Crenella*, *Adeorbis*, *Kellia*, and *Assiminea* are found in fair numbers between high and low tidal marks. The rock-borers and tunicata have had but cursory attention paid to them at present.

Some species are very local, being only found within a small rocky cove, or else confined to a limited zone on the wide sands either at Aberffraw or at Cymmeran, a few even are restricted to smaller patches of sand in one of the numerous little creeks along the coast.

Additions to the Mollusca.

CEPHALOPODA.

80. Sepia officinalis. The animal is occasionally caught in the dredges, nets, and lines of the fishermen, and the bone or shell is thrown on shore after a gale.
81. Sepiola Atlantica, seen at times in the deeper pools of the rock.
82. Octopus vulgaris. This singular animal has been taken, but it is very seldom kept, as its uncanny ways make it dreaded by the fishermen.
83. Loligo vulgaris, taken in the nets. It is probably common amongst the rocks, as my son saw the inky cloud discharged from one in a small pool as his boat passed over the spot.

ACEPHALA.

Fam. I.—Pholadidæ.

84. Teredo norvagica, portions of the tube found in wreck.
85. Teredo navalis. The tube of this common shipworm is found in old wreck floating into the bay, after months of drifting in the Atlantic or in the Channel.
86. Pholas candida. Specimens are rare; no doubt the absence of limestone rocks along this coast accounts for the rarity of the Pholadidæ.
87. Saxicava rugosa. A few specimens.
88. Mya truncata. A few perfect shells.

Fam. VI.—Anatinidæ.

89. Thracia phaseolina. One valve only.

FAM. VII.—SOLENIDÆ.

90. Solen ensis.
91. Solen marginatus.
92. Ceratisolen legumen.

FAM. IX.—TELLINIDÆ.

93. Syndosmya prismatica, one specimen, rare.

FAM. XI.—MACTRIDÆ

94. Lutraria elliptica, many *thick* valves, separated and broken by the gulls.

94*a*. Mactra elliptica, rare.

FAM. XII.—VENERIDÆ.

95. Venus verrucosa, small variety.
96. ,, casina.

FAM. XIII.—CYPRINIDÆ.

97. Circe minima, very rare, only one valve.
98. Astarte sp.?

FAM. XIV.—CARDIADÆ.

99. Cardium fasciatum, very rare.

FAM. XVI.—KELLIADÆ.

100. Montacuta ferruginosa, rare.
101. Turtonia minuta, one valve, rare.
102. Kellia rubra.

FAM. XIX.—MYTILIDÆ.

103. Crenella marmorata.

FAM. XX.—ARCADÆ.

104. Nucula decussata, rare, one valve.
105. Pectunculus glycimeris, rare, one valve.

FAM. XXI.—OSTREADÆ.

106. Pecten pusio, fine living shells, dredged.
107. ,, tigrinus, rare, one very small valve.
108. ,, opercularis, rare.
109. ,, niveus, rare.
110. Anomia striata, rare.
111. ,, ephippium, many varieties of this species, occur commonly at high water line, living specimens dredged.

PROSOBRANCHIATA.

112. Chiton, sp. These singular mollusca occur pretty commonly but the species are not yet satisfactorily identified.

Fam. XXVIII.—Patellidæ.

113. Pilidium fulvum, rare, one worn specimen.

Fam. XXXIII.—Trochidæ.

114. Trochus lineatus, very fine specimens about the rocks at low water—abundant.

115. Adeorbis subcarinata, a few specimens.

Fam. XXXVII.—Littorinidæ.

116. Littorina saxatilis, one specimen.

117. „ tenebrosa, and varieties.

118. Lacuna pallidula.

119. „ puteolus.

120. „ vincta, and varieties.

121. Assiminea Grayana.

122. Rissoa calathus.

123. „ ventrosa, dead shells

124. Skenea planorbis.

125. „ nitidissima.

126. „ rota.

Fam. XLI.—Pyramidellidæ.

127. Eulima polita.

128. Chemnitzia sp., uncertain until other specimens are found for comparison.

129. Odostomia conoidea.

130. „ rissoides.

131. „ unsculpta.

132. „ spiralis.

133. „ sp. uncertain.

Fam. XLV.—Muricidæ.

134. Nassa incrassata.

135. Fusus antiquus, brought up alive by dredging.

Fam. XLVI.—Conidæ.

136. Mangelia linearis.

FAM. XLVIII.—BULLIDÆ.

137. Tornatella fasciata, rare.

138. Scaphander lignarius.

TUNICATA.

FAM.—ASCIDIATÆ.

139. Ascidia mentula. I found a very fine one attached to a piece of slate, at a very low tide: it was nearly six inches long.

140. Ascidia sp. Several other forms have been seen, but not taken for preservation.

Crustacea.—Upon further exploration it has been found that the shrimp is a very rare species all along this coast, but that the prawn, *Palæmon serratus*, is very abundant.

The fishermen firmly believe that the lobsters and crabs are sensitive to coming violent changes in the wind and weather, and maintain that they forsake the neighbourhood of the rocks in the bay and go far out into deep water in the channel 24 to 48 hours before the storm breaks on the coast; for none are ever caught in the ports a day or two before the storm. That fishes leave the shallow waters of the bay for deeper water before a storm, is a fact for which I can myself bear testimony, as well as the fact that on warm quiet days and nights, when the water is oily and without a ripple, the fish frequent the bay in thousands.

The Crustacea, Balanidæ, Lepadidæ, Annelidæ, Echinodermata, Actinozoa, are only at present half ascertained, but a sufficient number of specimens have been obtained to make their further collection important; and these, together with the land and fresh-water shells, will be given in a future list of the fauna of Cymmeran.

Ordinary Meeting, December 14th, 1875.

EDWARD SCHUNCK, Ph.D., F.R.S., &c., President, in the Chair.

Professor SCHORLEMMER exhibited a sample of peat from lagoons in the Sierra Madre in Mexico. It is very dense and not readily inflammable, giving very little flame, but when once red-hot it burns completely, without requiring much draught, to a perfectly white ash containing much calcium carbonate and a little sodium sulphide, which is derived from glauber salt which the peat contains.

"On Graphic Methods of Solving Practical Problems" by Professor OSBORNE REYNOLDS, M.A.

In the first part of this paper it is pointed out that, when dealing with practical problems by the aid of the graphic method, it is not necessary to break off the operations of drawing, and find numerical values for the quantities represented, in order to perform on them the operations of multiplication and division. For by the aid of a parallel ruler the operations of multiplication and division may be performed graphically with great facility. The only geometrical proposition involved being that of finding a fourth proportional to three distances. When two distances have to be multiplied or divided the one by the other, a third distance is chosen equal to unity, and a fourth proportional found which represents the product or ratio of the first according as unity is the first or third of the given quantities.

The method was illustrated as applied to the determination of areas, centres of gravity, and moments of inertia.

In the second part of the paper a graphic method is described by which the velocity and acceleration of a moving point can be determined when the times at which it

occupies certain positions are known, *i.e.* the curves representing the velocity and acceleration of the point may be drawn from the curve representing the positions of the point. Also a converse method by which the position of a point at any time may be found from the curve representing either its velocity or displacement.

"On Explosions of Fire Damp."

E. W. BINNEY, V.P., F.R.S., said that the fearful loss of life in our coal mines deserved the careful attention of all societies like ours. It ought to be one of the objects of science to endeavour to find out the cause of these explosions and to devise some means to prevent their occurrence or lessen their frequency. No doubt Government Inspection had been of service, and the examination of managers would tend to improve the efficiency of mining officers; but still notwithstanding these improvements the explosions of fire damp are sadly too frequent. The lamentable events which have taken place during the last ten days clearly show that they sometimes occur without any great change in the barometric pressure of the atmosphere, although undoubtedly sudden depressions in a barometer ought to caution miners against emission of gas from the seam of coal and coal wastes, and put the men more on their guard at such times.

It has been stated in this society that certain conditions of the atmosphere quite irrespective of barometric pressure may have something to do with causing the "drag" in the currents of air circulating through a mine, as explosions have frequently occurred during an east wind and a muggy state of the atmosphere, and a vesicular condition of water in the air has been suggested as the probable cause of this lessening of the speed of the air passing through the galleries of mines. Now, careful observations with a good anemometer in the return air course of a mine ought to

determine whether or not such an effect is produced, and thus settle this point by direct experiment.

Another source of accidents at this time of the year has to be taken into consideration. Before Christmas and in cold weather there is often a brisk demand for coal, and both managers and men are in a hurry to increase the output, and under such circumstances probably there may be sometimes not so much care and caution exercised as are necessary for them to use in the dangerous work in which they are engaged.

In the management of a fiery mine, in my opinion,

1. There ought not to be any unventilated wastes.

2. The mixed use of Davy lamps and naked lights should not be permitted where the former are commonly employed.

3. Blasting of coal by gunpowder should not be sanctioned where Davy lamps are in common use.

4. An anemometer under the care of a competent man should be in constant use in order to see that a sufficient current of air is passing through the workings to insure perfect ventilation of the mine..

5. When there are marked indications of fire damp in a mine, shown by a cap on the flame of a lamp, the men engaged in hewing and drawing coal should be removed from the pit until by ventilation the place is cleared of gas and rendered safe for a working collier.

The above precautions may probably cause an increased cost in the getting of coal, but they are necessary for the preservation of human life if such catastrophes as now frequently occur are to be prevented. It is now pretty generally admitted that all explosions of fire damp are caused by there being too little pure air and too much of that gas in a mine.

"Chemical Notes," by M. M. Pattison Muir, F.R.S.E., Assistant Lecturer on Chemistry, Owens College.

I. *On the Solubility of Potassium Perchlorate in Water.*

Having a small quantity of pure Potassium perchlorate at my disposal, I thought it might be interesting to determine the solubility of this salt in water at different temperatures.

The apparatus employed was similar to that described by Hannay.*

The salt was placed in a small test tube to which a thermometer was strapped, the whole being surrounded with ice or water maintained at the proper temperature.

The following were the results obtained.

A. Temperature 0° C.

Weight of liquid in the bulb 4·722 grms.

Weight of residue on evaporation 0·0333 grms.

Weight of distilled water contained in the bulb at 0°, 4·7575 grms.

Weight of bulb itself, 5·3954 grms.

Hence the specific gravity of an aqueous solution of this salt saturated at 0° equals 1·0005: the percentage of salt in solution is 0·705: and the solubility of the salt is 1 part in 142·9 parts of water.

B. Temperature 25° C.

Weight of liquid in bulb 4·7418 grms.

Weight of residue on evaporation 0·0907 grms.

Other weights as before.

Specific gravity of aqueous solution saturated at 25°, 1·0123.

Percentage of salt in solution, 1·92.

Solubility, 1 part in 52·5 parts of water.

C. Temperature 50° C.

Weight of liquid in bulb 4·798.

Weight of residue on evaporation 0·243.

Specific gravity of aqueous solution saturated at 50°, 1·0181.

Percentage of salt in solution 5·07.

Solubility, 1 part in 15·5 parts of water.

* J. Chem. Soc. [2] xii. 203.

D. Temperature 100° C.

Weight of liquid in bulb 4·9965.

Weight of residue on evaporation 0·7870.

Specific gravity of aqueous solution saturated at 100°, 1·06603.

Percentage of salt in solution 15·76.

Solubility, 1 part in 5·04 of water.

For each rise of 25° the solubility and the percentage of salt in solution increase in round numbers threefold.

I may add that I found Hannay's apparatus exceedingly accurate and serviceable.

II. *On Basic Bismuth Perchlorate.*

If metallic Bismuth be heated with an aqueous solution of perchloric acid it is slowly converted into a white non-crystalline mass. This substance is insoluble in water; when thoroughly washed and dried between folds of blotting paper it presents the appearance of a bulky, pure white powder which it is difficult to obtain equally divided as the particles tend to gather together and form small more or less compact masses. This substance yields the following numbers on analysis:

(*a*) 0·364 grams gave 0·2675 grams Bi_2O_3 = 0·2382 grams Bi.

(*b*) 0·4173 „ „ 0·298 „ „ = 0·267 „ „

(*c*) 0·450 „ „ 0·3231 „ „ = 0·290 „ „

	Calculated for $BiO.ClO_4$	Found.		
		I.	II.	III.
Bismuth 210	64·52	65·44	63·98	64·44

These numbers agree very well with those required by the formula $BiO.ClO_4$, or it may be written $Bi(ClO_4)_3.Bi_2O_3$.

Basic Bismuth perchlorate is almost perfectly insoluble in water even at 100°; it is very readily dissolved by hydrochloric or nitric acid; less readily by sulphuric acid; at a red heat it is decomposed with formation of bismuth chloride which is slowly volatilised.

III. *On the Amount of Carbon Dioxide in the Air of Sea Coast Places.*

Thorpe (Chem. Soc. J. [2] v. 189) has shown that the air over the ocean contains less carbon dioxide than air over the land, the mean numbers being 3·0 and 4·04 vols. per 10,000 of air respectively.

During the long vacation I interested myself with a few experiments upon the air of the sea coast with a view to determine whether it inclined, as regards carbon dioxide, to sea air or to land air.

The samples of air were collected at *Ardrossan*, a small town on the firth of Clyde, where the river is almost entirely merged in the open sea.

The estimations were conducted in accordance with Pettenkofer's method.

Date, 1875.	Weather.	Place and Time.	Temp.	Barom.	Wind.	Vols. of CO_2 per 10,000 of air.
Aug 2.	Fine but cloudy.	In boat, ½ mile from shore; 12 noon.	16°·5	767mm.	W by S	3·87
,, 4.	Clear, cloudless sky. Sunset.	On shore, 8 p.m.	21°	760mm.	W by N	3·88
,, 14.	Fine, fresh breeze	200 yards from shore, 3 p.m.	21°	760mm.	SW	3·34
,, 18.	Fine, very clear; very heavy rain during preceding night.	On shore, 8.30 a.m.	16°	759mm.	NW	3·40
,, 21.	Fine, very clear; rain during morning.	In boat, ¼ mile from shore, 2.30 p.m.	17°·5	767mm.	NW	3·84
Sept. 3.	Fine, showers during preceding days.	300 yards from shore.	16°	759mm.	NW	4·01

Mean = 3·72 vols. CO_2 per 10,000 of air.

The air of such a place as Ardrossan, although it be situated almost in the open sea, is not therefore influenced by the sea, so far as the carbon dioxide is concerned, but contains almost the same amount of that gas as is found in land air.

Ordinary Meeting, December 28th, 1875.

EDWARD SCHUNCK, Ph.D., F.R.S., &c., President, in the Chair.

The following communication from Dr. JOULE, F.R.S., V.P., was read:—

Unsuccessful attempts have recently been made for the purpose of utilizing a modification of the common kite as a means of obtaining a view of the surrounding country. The machine in each instance rose only to fall violently to the ground after remaining in the air a very short time. These trials have brought to my recollection some experiments I made more than six years ago, but of which I did not publish the results, imagining that all such matters must have been thoroughly elucidated by the Chinese, if not by our own more juvenile kite flyers. The usual method of making the skeleton of a kite is to affix a rather slender bow to the top of a standard, tying the extremities of the bow to twine fastened to the bottom of the standard. The steadiness of the kite in the air depends on the fact that the wings yield with the wind. If the bow is too stiff and the surface nearly a plane, instability results. A kite ought to have a convex spherical surface for the wind to impinge upon. Such a surface I readily made by fixing two bows crosswise. The string was attached to a point a little above the centre of the upright bow, and a very light

tail was fastened to the lower end. The kite stood in the air with almost absolute steadiness. I found that by pulling strings fastened to the right and left sides of the horizontal bow, the kite could be made to fly 30° or more from the direction of the wind, and hence that it would be possible to use it in bringing a vessel to windward. One great advantage of such a mode of propulsion over ordinary sails would be that the force, however great, could be applied low down, so as to produce no more careening than that desired by the seaman.

E. W. Binney, V.P., F.R.S., said that in the Isle of Man there had been a prevalence of easterly winds throughout the months of October and November, such as he had never experienced during a residence of ten years. This appears to have influenced the migration of swallows. In the beginning of September the chimney swallows and the house martins assembled in great numbers on his buildings on Douglas Head, as they were accustomed to do prior to their annual departure, and disappeared. On the 5th of November, between 10 and 12 a.m., he observed a dozen house martins *(Hirundo urbica)* in front of his house and between it and the sea, busily employed in pursuing their prey. During the summer months the swift and sand martin are frequently seen in the same locality, but seldom the swallow or house martin, and he was inclined to believe that the presence of the latter was due to their having been driven out of their course by the easterly gales.

Ordinary Meeting, January 11th, 1876.

EDWARD SCHUNCK, Ph.D., F.R.S., &c., President, in the Chair.

"Note on a Method of Comparing the Tints of Coloured Solutions," by J. BOTTOMLEY, D.Sc.

In the last number of the *Chemical News*, January 7th, is a letter from Mr. Thos. P. Blunt, M.A., proposing a new method of ascertaining the quantities of bodies in solution by colorimetrical experiments. To two cylinders containing equal columns of the fluid to be examined for a certain substance he adds measured quantities of that substance, adding more of it to one cylinder than to the other; he then purposes to shorten the darker column until it corresponds in depth of tint with the other, then from the length of the two columns he calculates the quantity of the substance originally present. At the end of his letter, alluding to the method for shortening the column, he states "The appropriate apparatus mentioned above so far as I am aware is still a thing of the future." Mr. Blunt's suggestion with slight variation may be practically carried out as follows :— Take two cylinders of equal diameter; inside, at the bottom of each, place a white porcelain disk (the flat lid of a crucible will do). In these cylinders let there be equal columns of fluid. In one cylinder, which may be called A, let a tint be produced by a known quantity of the substance sought. Suppose B to contain this substance, and first sup-

pose the tint in B darker than A. Take a white porcelain lid and elevate it or depress it in B until the tint produced is the same as in A, then if the height of the column of fluid above the disk be h, and the total length of the column H, and p the weight of the substance in A, then the weight in B will be $\frac{p\,\mathrm{H}}{h}$. If the tint be stronger in A than in B, then the disk must be allowed to sink in A until identity of tint is obtained. It will be convenient to have the cylinders of equal radii. If they are not so, then if R be the radius of B and r the radius of A, the quantity of the substance sought in B will be $\frac{\mathrm{R}^2}{r^2}\,\frac{\mathrm{H}}{p}\,p$. Instead of supporting the string attached to the disk by the hand it would be more convenient for it to pass over a pulley and have a counterpoise at the other extremity

"On Explosions of Fire Damp," by ROBERT RAWSON, Esq., Hon. Member of the Society.

Mr. Binney has done wisely in calling the attention of the Society to the great loss of life in our coalmines by the explosion of light carburetted hydrogen. Surely the application of science may do a little good, even if its powers are limited to pointing out the advantages of order and obedience while contending with a foe so subtle and powerful as is carburetted hydrogen, and which is unfortunately so plentiful in many of the coalmines. My object now is to supplement the excellent rules recommended by Mr. Binney with a few observations which struck me in reading Mr. Binney's paper on this subject. Fire damp may be regarded as an enemy possessing terrible powers—and coalminers on the other hand may be regarded as an army whose mission

is to filch the black diamonds from the grasp of this powerful enemy with the least possible expenditure of life and force. In my opinion a little of military obedience and tactics might be introduced with advantage into the struggle maintained between the coalminer and the fire damp. It is well known that the safety of an army, when before an enemy, is much improved by keeping a good look out at a considerable distance and in every possible direction. Vedettes are usually stationed on the outposts of an army for the express purpose of watching the movements of the enemy, and to give timely notice of his approach. By this means the evils which frequently follow a surprise are considerably diminished, and sufficient time is given for the army to retreat or otherwise with advantage if the enemy is too strong. Many illustrations of this simple and obvious principle may be found in the common affairs of every-day life, but the above is sufficient to show the force of my argument in reference to the dangers met with in coalmines. Why the army of coalminers should be deprived of a system which affords so many obvious advantages is a question which should receive immediate and serious consideration from every lover of humanity. A system of vedettes should therefore be at once adopted in coalmines to watch the movements and strength of the fire damp.

1. A vedette, armed with ample knowledge of the properties of fire damp, should be placed at the various outposts of the mine where the enemy is likely to appear. His duty should be to watch, constantly and carefully, over the safety of the miners, and not allow them to remain at work until the enemy is upon them.

2. Miners should not be allowed to work where it is

unsafe to fire a shot or expose a naked light. For men to work several hours in an atmosphere highly charged with light carburetted hydrogen may be consistent with their desires to maintain their families in comfort and independence, but is hardly consistent with the wish of a great nation for the welfare of its mining population.

3. Unventilated wastes are magazines of dynamite, and according to Mr. Binney should be, if possible, avoided in coalmines.

4. System, watchfulness, and complete knowledge of the enemy's position and force, will no doubt diminish the probability of the happening of events which too often overtake the miners by surprise and fatal consequences.

5. A more palpable and delicate test of the presence and strength of fire damp should be supplied than the flame of a candle or Davy lamp.

I may add in conclusion my conviction, that the increased price of coal incident to the changes here alluded to would be cheerfully borne by the public, who would rejoice to see the adoption, at any reasonable cost, of a system which promises to reduce the fatal casualties in coalmines.

Ordinary Meeting, January 25th, 1876.

E. W. Binney, F.R.S., F.G.S., Vice-President, in the Chair.

"Stannic Arsenate," by William Carleton Williams, F.C.S., Demonstrator in the Chemical Laboratory of the Owens College.

A mixture of moderately concentrated aqueous solutions of stannic chloride and arsenic acid gradually thickens on standing, and after the lapse of two or three weeks solidifies, forming a transparent colourless noncrystalline mass. In order to ascertain the composition of this substance I subjected a considerable quantity of it to dialysis; hydrochloric acid and the excess of arsenic acid or stannic chloride passed through the dialyser, leaving a gelatinous residue of pure stannic arsenate. This jelly is heavier than water, it floats in a liquid having a specific gravity 1·135. Strong acids, and solutions of caustic potash or soda, dissolve it readily. In water it dissolves very slowly. From this aqueous solution certain reagents reprecipitate the arsenate of tin as a gelatinous mass, identical in its appearance, properties, and composition with the original jelly. These reagents are hydrochloric, nitric, and sulphuric acids, the chlorides of barium, calcium, ammonium, and iron, also silver nitrate and potassium iodide. Alcohol, acetic acid, sodium phosphate, mercuric chloride, and the carbonates of sodium, potassium, and ammonium, do not produce any change.

This substance contains a large amount of water, the greater part of which is expelled at a temperature of 100° C. A small quantity however is retained most pertinaciously, and is not driven off at 200°. Below a dull red heat decomposition takes place and fumes of arsenious oxide escape.

51·9 grm. dried at 100° C. left 1·9 grm. residue. Loss of water = 50 grm. or 96·3 per cent.

The residue somewhat resembles gum arabic in appear-

ance. It is soluble in strong hydrochloric acid and in aqua regia, but is insoluble in water, nitric and sulphuric acids.

Analysis of the residue gave the following results:

Wt. tkn.	gave		%	Avge.
0·3897 grm.	0·1696 grm.	SnO_2	= 34.4Sn	34.46 Sn
0·8214 „	0·359 „	„	= 34·52 „	
0·3013 „	0·2395 „	$MgNH_4AsO_4H_2O$	= 29·96As	29·82 As
0·5228 „	0·397 „	„	= 29·69 „	
0·7842 „	0·0801 „	H_2O	= 10·21H_2O	10·91 H_2O
0·852 „	0·099 „	„	= 11·62 „	

The simplest formula agreeing with these results is

$$Sn_2(AsO_4)_4 6H_2O.$$

	As	Sn	O	H_2O
Found	29·82	34·46	—	10.91
Calculated	29·46	34·76	25·18	10·6

Professor Reynolds, M.A., exhibited and explained the action of a Geissler's Light Mill.

Ordinary Meeting, February 8th, 1876.

Edward Schunck, Ph.D., F.R.S., &c., President, in the Chair.

Mr. W. A. Cunningham and Mr. W. Brockbank were appointed Auditors of the Treasurer's Accounts.

Professor C. Schorlemmer, F.R.S., read the following communication, which he received a short time ago from Professor Sadtler, of the University of Pennsylvania:—

"Since I heard from you I have been analysing some of the natural gases from the gas wells in Butler County, Pennsylvania, in the midst of the oil region.

"This gas has been brought in lines of piping eighteen miles to Pittsburg, and is used with great success as fuel in the rolling mills there, so the Geological Survey sent me to collect and analyse it.

"You will remember that Fouqué (*Compt. Rend.* 67,1054) analysed five of these natural gases from widely different localities and found them to be mixtures of the lower members of the paraffin series.

"I find free Hydrogen, Marsh Gas CH_4, Ethyl Hydride C_2H_6, and a trace of Butyl Hydride C_4H_{10}, with some little Carbonic Acid, in the two that I have already analysed. The hydrides of ethyl and butyl I collected qualitatively at the wells by passing the gas through absolute alcohol.

"The occurence of free hydrogen was an unexpected result, as Fouqué found none in any of the gases analysed by him; but its presence is proved by his own equations given for a mixture of the paraffin series."

Professor Schorlemmer added, that Dr. E. Ronalds, of Edinburgh, examined, in 1865 (*Journ. Chem. Soc.* 18, 54) the most volatile constituents of crude American petroleum, and found them to consist of homologues of marsh gas. Marsh gas itself was not present; but in conclusion he says: there appears to be little doubt that marsh gas and, perhaps, even free hydrogen will be found among the gases which are evolved with the oil at the springs.

"Notice of a recent discovery of a prehistoric burial place near Colombier in Switzerland," by William E. A. Axon, M.R.S.L., &c.

The *Journal des Débats* of Feb. 1st, 1876, cites from a Swiss paper a notice of an interesting archæological discovery in Switzerland. In sinking the foundations for a building now in course of construction on the border of the lake between Colombier and Auvernier, the workmen came upon some large pieces of stone each about one mètre broad and one mètre 50 centimètres long. These covered a series of cavities formed of flagstones surrounding the opening, which was filled with earth, pebbles, and gravel. The stones are blocks of various sorts of Alpine granite, evidently

fashioned by human labour at a very remote period. In one of the cavities were found fifteen skeletons, one of them being that of a child. The discovery of a bronze ring would appear to indicate that these individuals belonged to the bronze age, but there were also found a stone axe (nephrite), and bears' teeth pierced to form necklaces. The first grave was explored on the 24th January, and further examination was in progress.

Mr. Brockbank, F.G.S., exhibited a large collection of granites from the Ravenglass district, and from Criffel, which he had got together with a view to proving the origin of the large granite boulders recently found in the glacial clay or till of this district.

The fine boulder recently placed in this Queen's Park, and which was found in the railway cutting through the drift clay at Collyhurst, proves to be of Ravenglass granite, such as is found in Eskdale, about four miles above Ravenglass. It is a very fine example of a glaciated boulder, being polished and scratched on several sides, and very little weathered, so that it is pretty much in the condition in which it was when deposited in the clay.

Two large boulders were recently found in the foundations for the corporation buildings near the Manchester Exchange. One of these is of Ravenglass granite, of a deep red colour, such as is now found in the Muncaster Fell quarries about two miles from Ravenglass.

The other is a most interesting specimen differing greatly in appearence from the Queen's Park boulder, in being much weathered, and presenting no worn surfaces except one of its sides, and no ice markings. This may partly be accounted for by its having been found in the gravel, but the writer believed it to point to other glacial conditions than those which had obtained with the Collyhurst boulder. This granite appears to be identical with that now worked

in the Spy Crag quarry, near Dalbeattie, in the Criffel district, and if so it affords a most interesting evidence of the northernly origin of our drift current.

The red granite boulder which for many years stood at the end of the watering trough at Rooden-lane, and which now lies in the grounds of Mr. H. M. Ormerod, at Cheetham Hill, is of the red granite of Muncaster Fell, near Ravenglass.

It had been asserted by Professor Dawkins that the Queen's Park boulder was of Shap granite, but the writer is quite certain that this is not the fact, and he has never found any of the Shap Fell granites in the boulder clays of South Lancashire.

E. W. Binney, V.P., F.R.S., said, since the publication of his paper on the Drift Deposits of Manchester in Vol. VIII. (second series) of the Society's Memoirs, attention had been directed to the preservation of large boulder stones. The date of that memoir was 1847, and in it was described and figured the fine block of grey granite now placed in Peel Park. It was found in the till or brick clay at Park Place, Higher Broughton, just below the house then occupied by Mr. W. Sale, and remained on the road side till about the beginning of 1850, when the owners of the land were digging a hole to bury the stone, and thus get it out of the way. He wrote a letter to the Editor of the *Manchester Guardian*, which appeared in that paper of the 13th February, 1850, suggesting that the Peel Park Committee should fetch the stone and place it in their park. His appeal was responded to without loss of time, and it now is placed at the entrance to the park. He was glad to find that the preservation of this specimen had been of service in saving other large boulder stones from the rite of burial. He had himself seen the fine specimen of red granite placed in the Park at Macclesfield, and the large block of hard green stone, weighing nearly 20 tons, now preserved in the Oldham Park. It

was very desirable that when any more specimens are met with they should be preserved in the public parks, or some other suitable places for the inspection of the public. Lancashire and Cheshire contain many large boulders, and it is to be wished that they should not be buried near to where they are found, so as to get rid of them. In his remarks on the building stones of Manchester in 1856, Vol. I., p. 194 of the Proceedings of the Society, he stated: "By the facilities which railways now afford one might have expected that some of the beautiful syenite of Shap, containing large crystals of felspar or the grey syenite of Bootle and Ravenglass would have made their appearance in Manchester, but to my knowledge none of them have been used. It is possible they may not have been known to our architects." He was glad to say that the former stone had been introduced into the buildings of our city, and, when polished, had a beautiful appearance. It was a granite of very marked character, and could not easily be mistaken. After a search of forty years he had never found a specimen of it in the drift near Manchester, and when he heard from the newspapers that a block had been discovered at Collyhurst, and placed in Queen's Park, he went to look at it, but that stone was certainly not Shap granite, a rock which he had several times carefully examined in the quarry at Wastedale Head. It was a grey granite, and it was difficult to speak with certainty whether it came from Ravenglass, Dalbeattie, or the Isle of Man, as specimens from those places are much alike, and it would require to be carefully analyzed by a chemist before it could be identified.

"On the formation of Azurite from Malachite," by CHARLES A. BURGHARDT, Ph.D.

Two years ago I placed a specimen of rather poor Malachite (from Alderley Edge) on a rockery in my garden where it would be exposed to the action of the weather, in

order to ascertain whether any change would take place in its composition. Last December I examined the specimen and found it had been acted upon by the weather to a considerable extent, as specks of a dark blue mineral were distributed here and there upon its surface. This dark blue mineral proved to be Azurite. Messrs. Wibel and Tüngel (Dent. Chem. Geo. Berichte IV. 138), in a short paper on the formation of Azurite state that it is formed from Malachite by the absorption of carbonic acid and elimination of water, as Azurite contains a much larger percentage of carbonic acid than Malachite. This statement still remains to be proved, but it is scarcely probable that the moderate heat of our last two summers was sufficient to cause a loss of water in the Malachite specimen. At some future time I shall endeavour to ascertain the real cause of the formation of Azurite.

"On a Direct-Vision Spectroscope of great Dispersive Power," by ARTHUR SCHUSTER, Ph.D.

This instrument is made by Mr. Adam Hilger of London. The following are its chief advantages:—

1. The compound prism has a very great dispersive power. The nickel line between the two sodium lines is easily seen in the solar spectrum.

2. The cross wire is replaced by a very fine slit which can be illuminated from above to any degree of intensity.

3. The slit is moveable by means of a very fine micrometer screw; the position of the slit can be read off to within 0·0001 inch.

The measurement is made by bringing the line to be measured against the bright slit which comes down from the top to the middle of the field. The position of the lines can be easily measured to within the fifth part of the distance between the sodium lines.

"On a New Absorptiometer," by ARTHUR SCHUSTER, Ph.D.

In some recent researches Professor Vogel found that the relative intensity of the red and blue part of the solar spectrum was subject to great changes. While working with the spectroscope at considerable heights on the southern slope of the Western Himalayas, I was struck by the same fact. The instrument which I have now the honour to exhibit before the Society is constructed in order to measure the relative intensity of the red and blue light in the solar or any other spectrum, by comparing the intensity of each ray with that given out by a standard lamp. The photometric principle involved in the measurement is that first used by Professor Zöllner. The intensity of a certain part of the spectrum is brought to the same intensity as that of the standard light by a system of Nicol's prisms. Professor Zöllner only compared the whole intensity of two sources of light and did not investigate the relative intensity of the different colours. D. Glau constructed another apparatus by which he could measure the relative intensity of different colours, but his instrument was constructed for an entirely different object, and is not suitable for the purpose for which the present instrument is made.

The instrument, which I have called absorptiometer, because it is intended chiefly for the determination of the absorption of light taking place in our atmosphere, consists of a table similar to that of a goniometer table, but being able to turn round on a horizontal axis so as to give it any inclination to a horizontal surface. The telescope of the goniometer is replaced by a direct-vision spectroscope. Opposite the spectroscope a tube is fixed to the table containing two Nicol's prisms. One of the prisms is fixed, the other can be turned, and its azimuth read off on a graduated circle. The standard light is placed behind its tube. The intensity of the light falling unto the slit of the spectroscope is $\frac{A}{2} \sin a$, where a is the angle between two of the principal planes of the two Nicol prisms, and A the

intensity of the light which would fall into the slit of the spectroscope if the Nicol's were removed.

A plane parallel piece of glass, acting as mirror, is fixed unto the small table, the centre of which coincides with the centre of the large goniometer table. The parallel sides can be adjusted by means of 3 screws until they are vertical. This mirror reaches to such a height that the horizontal plane laid through the top of the plate would bisect the tube containing the two Nicols.

The light which is to be examined falls through a tube containing one Nicol, and is reflected by means of the plane parallel mirror into the lower half of the spectroscope. If the ray of light is reflected at the angle of polarization the intensity of this light can be reduced to nothing by means of the rotation of the Nicol.

On placing the standard light in front of the tube containing the two Nicols and allowing the light which is to be examined to be reflected into the spectroscope on the mirror through the tube containing one Nicol, the mirror being placed at the angle of polarization, we observe in the spectroscope the two spectra one above the other, and by turning the Nicols we can reduce the intensity of the brighter light to that of the weaker for any colour we like. The positions of the Nicols will enable us to find the relative intensity of the two lights for the different colours.

MICROSCOPICAL AND NATURAL HISTORY SECTION.

December 6th, 1875.

CHARLES BAILEY, Esq., Vice-President of the Section, in the Chair.

Mr. SIDEBOTHAM, F.R.A.S., sent for exhibition some sand from a river far inland of New Guinea, containing particles of gold, magnetic and non-magnetic iron, foraminiferæ, silicified fragments of echini, and shells.

Mr. J. Cosmo Melvill exhibited two specimens of the Spurge Hawk Moth (Deilephila Euphorbiæ); said to have been captured in the larval state at Ecclesbourne, near Hastings, feeding in all probability on Euphorbia Amygdaloides, as he subsequently visited the spot and could see no trace of any other Spurge.

January 17th, 1876.

John Barrow, Esq., in the Chair.

Mr. Sidebotham, F.R.A.S., exhibited a magnified drawing and specimens of lymexylon navale from Dunham Park, and read a short paper on the life history of the insect, which he and Mr. Chappell had studied since its discovery in Dunham Park in 1872. Previously to that time only one authentic British specimen was known; this was found at Windsor nearly fifty years ago.

The species is very abundant in some of the old oak trees in Dunham Park, but specimens are difficult to capture, as they fly about the tops of the trees, and to obtain them a net attached to a very long pole is required.

Mr. Sidebotham also read a paper on Psammodius Sulcicollis, and exhibited specimens taken at Southport in 1875. This has been considered a very rare species, but its habits being now known, it is easy to obtain a comparative abundance. It buries itself in the dry sand at the foot of the sandhills during the day, coming out about 5 p.m.

Mr. Plant exhibited various objects of interest, including a longicorn Beetle (Astinomus ædilis) from a coal mine near Manchester; also cases of a N. American caddis worm (Phryganea sp.) much resembling a mollusk of the genus Valvata, and once named by Lea Valvata arenicola.

Ordinary Meeting, February 22nd, 1876.

EDWARD SCHUNCK, Ph.D., F.R.S., &c., President, in the Chair.

"Notes on a Collection of Apparatus employed by Dr. Dalton in his Researches, which is about to be exhibited (by the Council of the Literary and Philosophical Society of Manchester) at the Loan Exhibition of Scientific Apparatus at South Kensington," by Professor ROSCOE, F.R.S.

The apparatus employed by John Dalton in his classical researches, whether physical or chemical, was of the simplest and even of the rudest character. Most of it was made with his own hands, and that which is to be exhibited has been chosen as illustrating this fact, and as indicating the genius which with so insignificant and incomplete an experimental equipment was able to produce such great results. The Society has in its possession a large quantity of apparatus used by Dalton, most of which however consists of electrical apparatus, models of mechanical powers, models of steam engines, air pumps, a Gregorian telescope, and other apparatus of a similar kind, which was either bought or presented to him. It has not been thought necessary to exhibit these, but rather to show the home-made apparatus with which Dalton obtained his most remarkable results.

I. *Meteorological and Physical Apparatus made and used by Dr. Dalton.*

Throughout his life Dalton devoted much time and attention to the study of meteorology; indeed his first work, published in 1793, was entitled "Meteorological Observations and Essays," and his last paper, printed in 1842,*

* *Vide* Life of Dalton by Dr. Henry, published by the Cavendish Society; Memoir of Dr. Dalton and the History of the Atomic Theory, published in the Memoirs of the Literary and Philosophical Society of Manchester, 2nd Series, Vol. 1; Dr. Lonsdale's Life of Dalton, Longmans, 1874.

(Mem. Lit. and Phil. Soc. VI. 617), consists of auroral observations. Hence the first of Dalton's apparatus which claims attention are the meteorological instruments.

No. 1 is Dalton's mountain barometer, with accompanying thermometer, made for him by the late Mr. Lawrence Buchan, a member of the Society. The barometer is enclosed in a wooden case which Dalton was accustomed to carry in his hand.

Several home-made barometers used by Dalton in his observations are in possession of the Society. They are all of them filled, and the scales prepared, by Dalton himself, and are simple siphon tubes with a bulb blown on at the bottom to serve as a mercury reservoir. These are attached to plain pieces of deal upon the upper part of which the paper scale is pasted. One of these, which has probably also served for tension experiments (No. 2), has been placed in the collection.

Many of the thermometers appear also to have been home-made. No. 3 is a mercurial thermometer evidently made and graduated by Dr. Dalton, and marked with his initials, J. D. The freezing point of this thermometer was tested recently by Mr. Baxendell, who found that it had not altered since the instrument was graduated. Another (No. 4) is of the same kind and bears the date 1823; No. 5 is a third mercurial thermometer with long stem and wooden scale; No. 6 is an alcohol thermometer with wooden scale; and No. 7 a registering maximum and minimum thermometer employed by Dalton, maker's name J. Ronchetti, 29, Balloon-street, Manchester.

II. *Apparatus Constructed and Used by Dalton in his Researches.*

(1) "On the constitution of mixed gases," (2) "On the force of steam or vapour from water or other liquids at different temperatures both in a Torricellian vacuum and

in air," (3) "On evaporation," and (4) "On the expansion of gases by heat."*

No. 8 is an apparatus used for the determination of the tension of volatile liquids at low temperatures; it consists of a siphon tube, at the upper end of which is a scale in inches in Dalton's handwriting. He describes it thus:

"I took a barometer tube 45 inches in length, and having sealed it hermetically at one end, bent it into a siphon shape, making the legs parallel, the end that was closed being 9 inches long, the other 36 inches. I then conveyed 2 or 3 drops of ether to the end of the closed leg and filled the rest of the tube with mercury except about 10 inches at the open end. This done, I immersed the whole of the short leg containing the ether into a tall glass containing hot water."

No. 9 is a smaller tube containing another liquid, also having a graduated scale written on paper and attached to the tube. Nos. 10, 11, 12, 13, 14, are tubes used by Dalton for measuring the tension of vapour from water and other liquids at higher temperatures than their boiling points, both in a vacuum and air. No. 15 is a tube used by Dalton for measuring the tension of the vapour of bisulphide of carbon, labelled "Sulphuret carb.," with a paper scale in Dalton's handwriting, and a cork showing that the upper portion of the tube containing the bisulphide of carbon could be heated in a water bath to various temperatures. No. 16 is a manometer tube, fixed into a board, divided and numbered by Dalton. No. 17 is an apparatus used by Dalton for the determination of the tension of the vapour of ether, and is interesting as being the instrument by means of which Dalton arrived at one of his most important experimental laws. It is described as follows (p. 564):—

* Experimental essays on the above subjects, by John Dalton, read October 2nd, 16th, and 30th, 1801, and published in the 1st series, vol. 5, part 2, of the Memoirs of the Literary and Philosophical Society of Manchester.

"The ether I used boiled in the open air at 102°. I filled a barometer tube with mercury moistened by agitation in ether; after a few minutes a portion of the ether rose to the top of the mercurial column, and the height of the column became stationary. When the whole had acquired the temperature of the room (62°) the mercury stood at 17·00 inches, the barometer being at the same time 29·75 inches. Hence the force of the vapour from ether at 62° is equal to 12·74 of aqueous vapour at 172° temperature, which are 40° from the respective boiling points of the liquids."

This is generally known as Dalton's law of tensions, since shown by Regnault not to be rigorously true.

No. 18 is a wet and dry bulb mercurial thermometer made by H. H. Watson, of Bolton.

III. *Apparatus for Measuring Gases, and for determining the Solubility of Gases in Water.*

No. 19 is an apparatus with a graduated tube, probably used by Dalton for the determination of the laws regulating "the absorption of gases by water and other liquids," read October 21st, 1803*. No. 20 is a graduated glass tube attached to a bottle of indiarubber, also probably used in his researches on the absorption of gases by water. No. 21, No. 22, are divided endiometer tubes, employed by Dalton for measuring the volumes of gases. No. 23 is a spark eudiometer; Nos. 24, 25, 26 are glass tubes, pipettes, and funnels graduated by Dr. Dalton and used by him for measuring gases; No. 27 is a graduated glass bell-jar, used for measuring gases; No. 28 is a phial, with graduated tube attached by cement, for collecting and measuring gases; Nos. 29, 30 are stoppered phials with the bottoms cut off, used as gas jars for collecting and measuring gases; No. 31 is a thousand grains specific gravity bottle, with its counterpoise of lead stamped "175" and paper labelled "bottle

* "Manchester Memoirs." 2nd Series. Vol. 1.

balance;" No. 32 is a pipette; No. 33 square bottle of thin glass, fitted with brass caps, and probably used for the determination of the specific gravities of gases; No. 34 is an earthenware cup, used by Dalton as a mercury-trough, and containing a small phial with mercury; Nos. 35, 36 are bulb-tubes, with graduated scales which may have served for the determination of the coefficients of expansion of gases; No. 37 is a Florence flask with cork and valve for determining the specific gravity of gases; No. 38 is a glass alembic.

IV. *Weights, Balances, Apparatus, Reagents and Specimens used by Dalton.*

No. 39, eleven phials, containing creosote, iodine, amalgam of bismuth and mercury, quercitron bark, grana sylvestra cochineal, and other substances, labelled in Dalton's handwriting. No. 40, three divided blocks, used by Dalton for the illustration of his lectures; these are not, however, the balls an inch in diameter (referred to in his latest memoir on the "Analysis of Sugar") which he employed occasionally in his lectures, as illustrating his newly-discovered laws of combination and the atomic theory; these appear, unfortunately, to be no longer in existence. No. 41 is a common pair of scales used by Dalton; No. 42, a pair of apothecary's scales and weights employed by Dalton, with a paper of weights made of wire, labelled in his handwriting, "100th grains." No. 43 is a box of weights used by Dalton, and containing a pill box labelled "Platina," another pill box labelled "Hund," and containing 100th of grains, and another wooden box containing brass gramme weights, labelled "Weights, French;" the other ordinary weights are of lead. No. 44 is Dalton's pocket balance, consisting of a small pair of apothecaries' scales, with beam about 4 inches long, and having the pans attached by common string; it is contained in a tin case for the pocket.

No. 45 is a penholder used by Dalton. No. 46, leaden grain weights made by Dalton from sheet lead, and stamped in numbers by him; No. 47, iron punches used by Dalton for this purpose. No. 48, a glass lens, wrapped in a piece of paper labelled, in Dalton's writing, "Sun's focus 4·2 inches." No. 49 is a paper containing "10th of grains," made by Dr. Dalton of iron wire. The paper in which these are wrapped is part of a note from one of Dr. Dalton's pupils (as is well known he lived by teaching mathematics at half-a-crown per lesson), in which the writer presents his "compliments to Mr. Dalton, and is sorry that he will not be able to wait upon him to-day, as he is going to Liverpool with a few friends who are trying the Railway for the first time. Mr. D. may fully expect him on Monday at the usual time." No. 50 are bottles of tin, earthenware, and silver, some of them being common penny pot ink bottles. Each has a thermometer tube cemented into the neck of the bottle, and these tubes are provided with paper scales. These were used by Dalton probably for experiments on radiant heat. No. 51 is a manometer tube used by Dalton; it consists of a tin vessel attached on either side to leaden tubing, and having a thermometer-tube closed at the upper end, and provided with a divided scale, fixed into the upper portion of the tin vessel. No. 52, Dalton's balance, made by Accum, and capable of arrangement as hydrostatic balance, with weights and counterpoises.

The following letter from Mr. ARTHUR WM. WATERS, dated Naples, February 9th, 1876, was read by Mr. BAXENDELL :—

Having expected to return ere this, I thought that, in the conversational hour before papers are read, I should have been able to say a few words on the Aquarium at Naples, where I have been working for six weeks, the British Association Committee for the establishment of zoological

stations, having granted me their table; but having, for the purpose of getting further acquainted with the fauna of the Mediterranean, become connected with the institution for a short time, I shall not be in England until after the last meeting of the session, and so send a letter that you may read, if you see fit, when there is a dearth of subjects for conversation.

The zoological station is connected with an aquarium which is more generally known, but is the least important part of the institution, and it was for the sake of the former that the undertaking was started and has been carried on by Dr. Dohrn. There are, in rooms above the aquarium, tables for twenty-four to work, and the greater part of these have been taken up by different governments, but some by other institutions—as the British Association and the University of Cambridge, and Dr. Dohrn is anxious the whole number should be taken, in order to place the station in a satisfactory position.

As the full advantage of such stations are not known to all, a word or two on the opportunities for scientific utility may perhaps have an interest for some of my friends of the Manchester Literary and Philosophical Society.

The station has been established by Dr. Dohrn two years, when he built, as I have before said, an aquarium, together with convenient rooms for study, library, and museum. As the most important direction of zoological research is at the present moment embryology and the study of development, it is natural that it should be principally used for advancing science in this direction, and, as I shall show, in no branch are the advantages more felt; and although this, I believe, was fully appreciated by Dr. Dohrn, when he determined to erect an aquarium at Naples, it was not merely with the idea of advancing zoology in this branch, but that naturalists should have the opportunity of using it for any purpose which they found might forward the branch of science they

had taken up. The greater number who have used the tables here have followed up the embryology of some group or species, but others have worked at the anatomy either of an organ or, on the other hand, of a class or species. I found that it presented great advantage for studying systematically a group, and in the six weeks during which the British Association granted me their table, I have been able to make a large collection of Bryozoa, the determination of which I have not been able to complete, as I cannot obtain some of the most important literature on the subject here; but I may say that I have over one hundred species and expect to find it not under one hundred and fifty, and probably it will be the largest number obtained from any one locality. These I have collected for the purpose of comparison with my collection of Bryozoa from various periods of the tertian formation.

For the study of embryology it is necessary that a very large nnmber of animals should be collected, and that often continuously for a long time; and this is a difficult and expensive thing for a naturalist, especially in a foreign town, but as the station has two fishermen, with a very large knowledge of the animals, who are out every day with instructions to bring such animals as are wanted at the time, and as the fishermen in the whole neighbourhood are encouraged to bring anything rare or that is wanted at the time, it will be clear that for such studies or other anatomical work the advantages are very great, and I have found the same advantage of having the opportunity of constantly overhauling a considerable amount of material for the systematic study of any group of smaller animals. Each worker has a good-sized tank and two smaller ones for keeping anything he requires alive. Besides having the animals or plants collected which each is studying, he has on the working table all the reagents which are ordinarily required, besides glass vessels, drawing materials, and cer-

tain simple apparatus, so that the naturalist on his arrival may find at once what he requires for his studies, and can directly set to work; and further, finds a very considerable library of zoological works, which is especially rich in the department of embryology. This was for a large part Dr. Dohrn's private library, but by presents from authors and publishers it has now become a very important library, numbering about three thousand volumes, but being comparatively very recent it is not a matter of surprise that with systematical works it is but very poorly supplied, but in time, by gifts and purchases, it will no doubt possess the most important for determining the fauna and flora occurring here. I should strongly advise any naturalist who intends to study to previously obtain the catalogue, that he may know what books that he is in the habit of using he had better bring with him.

Another very important feature is collecting and preserving the animals brought, so that there is a stock of certain animals in alcohol always ready for anyone who may require it, and supplies are constantly being sent to all parts of Europe to those who require the material for study, and are sent at about cost price. At the present moment there is an application from a neighbouring Literary and Philosophical Society for a supply of Amphioscus in various preservative solutions. A few animals have been determined by specialists who have worked here, and this will form a nucleus of a museum of the fauna and flora of the Bay of Naples. The specimens as yet determined in this manner are too few to have much importance, but when the collection is more considerable it will be very useful, as any one sending for specific specimens can feel more security in the determination when this is necessary.

Besides the knowledge of the fauna and flora, which can be gained by the material brought daily by the fishermen, those who are working here have the opportunity from

time to time to go out dredging; and it is to be hoped that a commencement may be made this spring of systematically dredging in the Bay, so that gradually a very complete knowledge may be gained of the nature of the Bay and the condition of depth and soil, with reference to the various animals found; but this can be carried out much more satisfactorily when the station has the steamer which has recently been presented by the Berlin Academy for the purpose of dredging.

As I indicated above, the expenses of this station are partly supplied by different governments and institutions who pay £75 per annum for a table; in some cases two governments have jointly taken a table, and the tables are granted to those who wish to proceed to Naples for study. At present, England has but two, *i.e.*, the Cambridge University and the British Association; but probably Oxford will soon take one, and why should not Owens join with the other Northern Universities, or with London, to take one?

"On Glacial Action in the Valley of the Wear, etc," by Professor T. S. Aldis, M.A.

The coal workings in the county of Durham have revealed the existence of a great depressed trench excavated in the coal measures, and partly filled in with drift. The part best known stretches from Durham to Newcastle in nearly a straight line, the Team Valley being the upper visible portion of it, the lower part being filled in for nearly 200 feet.

There is, I believe, no doubt that this "Wash" is the old valley of the Wear.

The glaciers filled up this trench to such an extent that the river, when set free again, often failed to find its former valley—in fact was altogether thrown to the east at Chester-le-Street, entering the sea by a post-glacial valley, though possibly guided in forming it by a dene or glen previously existing.

This diversion of rivers by glacial action is referred to by Geikie, in his "Great Ice Age," but the Wear gives better instances than I imagine can elsewhere be found.

Above Durham the river meanders through a valley resembling that of the Irwell opposite Kersal-moor, one or both of the opposite banks being composed of drift. At Durham itself a firm dam of clay has been thrown across the old valley, and the river has cut a narrow horseshoe-shaped ravine in the solid rock, thus isolating the block of stone on which the cathedral and castle stand. As soon as the stream emerges again from the rock into the pre-glacial valley, the bounding cliffs fall back, and the valley widens below as above the town. The narrow isthmus which joins the isolated block of rock is called Clay-path, and the boulder-clay in it is decidedly tough.

There are other instances of this clay-bar across the old river valley, and the isolation of a block of rock connected with the opposite side by a clay mound which has usually by this time weathered much lower than the isolated rock above which at first it must have risen. There is a very beautiful example of this (one amongst many) on the Esk, by Lealholm Station, near Whitby.

At Sunderland Bridge Station on the N.E.R. main line to the south of Durham is one of these diverted channels, half cut down. The river has begun a semi-circular ravine in the solid rock, but after it had dug down some 40 feet the clay barrier failed, and the ravine is left apparently purposeless. The Sunderland-bridge Railway Station stands in the hollow, and the railway forms the sagitta, whilst the viaduct across the present valley of the Wear beyond marks the site of the former clay barrier. Narrow, rocky-sided, and deserted river valleys will therefore be usually of post-glacial formations.

This Wash, or old valley of the Wear, proves that before the glacial period the north-eastern part of England was at

least some 300 feet higher than at present, for a rise of some 200 feet would push the sea much further off, and yet only bring the bottom of the Wash at Newcastle about to sea-level.

The depth of these old effaced river-beds gives us surely the best index of land elevation in old times, and several interesting conclusions follow from it.

Rock stretches, I believe, close to the surface of the ground all across the mouth of the Tees estuary. If then we raise the land to pre-glacial elevation, the Tees valley here should be sunk some 200 feet below the surface. The Tees therefore, we may assume, in pre-glacial times flowed southward into the Ouse, as the Wear flowed northward into the Tyne.

The York plain and the vale of Malton represent the filling in of valleys whose rock bottoms, in the case of the plain of York, may be 200 or 300 feet below the present surface.

The section of the ravine excavated by the Wear since the glacial period is at least, I judge, forty times less in area than that excavated before. How old, then, are our English rivers?

It is therefore, I think, a tolerably safe rule that all narrow rocky valleys are post-glacial,—*e.g.*, I have no doubt the Nidd at Knaresbro', the Derwent at Castle Howard, Swale at Richmond, Esk at Whitby harbour, are cases of post-glacial section. In several of these cases we can see clearly the old filled-up valleys. The Derwent apparently formerly flowed out by Gilling, on to Pilmoor, &c., &c.

It is stated that scratched flints occur at the top of boulder-clay a little to the north of Sunderland. If this be so it proves that at the close of the glacial period there were chalk beds to the east, off Sunderland, in continuation of the York wolds, at such a height as to send glaciers backwards when the great ice-sheet had so far lessened as to permit the free play of ice on minor slopes.

Do the clay dams across the pre-glacial Wear valley and other similar valleys mark epochs in the decline of the ice when the retiring glacier for a time advanced again and mounted up a huge mass before it ? It is possible, of course, that they do not really differ from the rest of the denuded drift, but on the other hand they appear in some degree to correspond in Weardale and Eskdale, the to two cases I know best. Lealholm corresponds to Bishop Auckland : above these points in both valleys I have not noticed any great filling-up of the valleys. One can even fancy a correspondence between some of the clay dams in the one valley and in the other as regards relative position and completeness.

Mr. Thomas Carnelley, B.Sc., exhibited and explained the action of Edison's Electric Pen.

Ordinary Meeting, March 7th, 1876.

Edward Schunck, Ph.D., F.R.S., &c., President, in the Chair.

Mr. R. S. Dale, B.A., exhibited Specimens of Crystals of Sulphate of Lead found in Alum Residue, and said that "In the manufacture of pure red liquor (alumina acetate), lead sulphate occurs as a bye-product from the admixture of alum and lead acetate. This lead sulphate is filtered to a stiff paste. In a cask of this pulp the very curious crystals I exhibit were found embedded in the centre of the mass, and, so far as could be seen, unattached. These crystals resemble the axes of a crystal of the *regular system*, and are undoubtedly pseudomorphs from crystals of alum. Lead sulphate in the crystalline state belongs to the *Rhombic system*. In the same cask crystals of alum were found, which leaves little doubt that such was the origin of these extraordinary forms. Analysis showed them to consist of lead sulphate."

"On the Degree of Accuracy displayed by Druggists in the Dispensing of Physicians' Prescriptions in different towns throughout England and Scotland,"* by WILLIAM THOMSON, F.C.S.

The results obtained by Mr. Allen, the public analyst for Sheffield, a short time ago in reference to the inaccuracies displayed by druggists in making up prescriptions, led me to believe that it would be interesting to have the same prescription dispensed by different druggists, in different parts of England and Scotland, and by analysis to decide the *range* of inaccuracies, if any. By the aid of my friend, Dr. Sinclair, of Manchester, to whom I am indebted for much subsequent help, I was furnished with two ordinary prescriptions, the principal ingredients of which admitted of very accurate determination, as I shall afterwards show.

The prescriptions were as follows :—

℞. Potass Iodid..... ʒij	℞. Zinci Sulphat. ℈ij
Sp. Chlorof..... ʒj	Aq. Pur..... ℥ij
Aq. ad ..... ℥vj	M. Fiat Lotio.
M. ℥ss ter die.	

The processes of analysis were so simple for both that it leaves little doubt as to the accuracy of the results. The specific gravity of each solution was first taken. 100 grains measure at 60° Fahr. were then placed in clean, accurately tared and marked platinum capsules, weighing from 180 to 200 grains each; the fluids were then carefully evaporated to dryness on a water bath, those containing the potassium iodide being afterwards heated in an air-bath at 220° Fahr. till they ceased to lose weight, whilst those containing the zinc sulphate were dried at 220° Fahr. and afterwards heated to dull redness to drive off the last molecule of water

* The facts contained in this paper were accepted by the Committee of the Pharmaceutical Society of Great Britain, to be read before them, and subsequently, on the day advertised by them for its reading, rejected by the Council.

of crystallization, and the anhydrous zinc sulphate calculated into the crystalline or hydrated zinc sulphate; these prescriptions, then, contained no ingredient which could interfere with the direct determination of the salt introduced. I give the dispensers, in this paper, the advantage of not estimating the actual proportion of the pure salt, but the total, of what had been added by them. The first prescription should have been made up to a total fluid measure of 6 ounces (2625 grains) which quantity should have contained 120 grains of potassium iodide. The second prescription should have been made by adding 40 grains of crystallized zinc sulphate to 2 ounces of water, which would make a total fluid measure of 893 grains, but as few gave either the exact measure of liquid, or weight of solid, I found it necessary to make three columns of figures, in the following tables, for each prescription; the first to show the amount of liquid measured out; the second to show the total amount of solid weighed out; and the third, as a comparison of the actual strength of the different fluids, which is made by calculating the amount of potassium iodide which would be contained in exactly 6 ounces (2625 grains measure) of the mixture, and the amount of zinc sulphate which would be contained in exactly 893 grains measure of the lotion, supplied by each druggist.

It will, of course, be clearly seen, that if the potassium iodide or zinc sulphate were damp, or in bad condition, although the weighings may have been made with absolute accuracy, the actual amount of the salts found on analysis would be less than that weighed; but this is equally a fault, because dispensers ought to have all their drugs in good condition. The following table will show the results of the analysis of eighty-one samples of the potassium iodide mixture, and the same number of the zinc sulphate lotion, one sample of the mixture, and one of the lotion, having

been dispensed by each druggist; besides which, at the suggestion of Dr. Sinclair, I have annexed the prices charged by each, for the two bottles, as in his opinion it might prove of general interest to dispensers, and will make the table more perfect, because from those who charge most, the greatest degree of accuracy should be expected. I may further state, that from each important town, I endeavoured as far as possible to have one lot dispensed by a druggist having the highest reputation and another by one of the lowest class, but I found it difficult to carry out this exactly, so that the prescriptions have been made up more generally by high class or respectable druggists than by those of a lower class. 1 have, however, as far as possible, marked those who could be recognised as having decidedly large and respectable shops, and those that were decidedly low class; the others may all be accepted, I believe, as respectable, and many may even be termed high class druggists.

Table I.

No.	Name of Town, &c.	Designation of Shop.	Prescription containing Iodide of Potassium. Total amount of Fluid measured out by the Druggist. Grains, measure.	Total amount of Potassium Iodide weighed out by the Druggist. Grains, weight.	Strength equal to amount of Iodide contained in 6 fluid ounces. Grains, weight.	Prescription containing Sulphate of Zinc. Total amount of Fluid measured out by the Druggist. Grains, measure.	Total amount of Zinc Sulphate weighed out by the Druggist. Grains, weight.	Strength equal to amount of Sulphate contained in 893 fluid grs. (about 2 ozs.) Grains, weight.	Prices. s.	d.
			According to the prescriptions the solutions *ought* to contain,							
			(6 oz.) 2,625	120	120	(about 2 ozs.) 893	40	40		
	Scotland.									
1	Aberdeen	Large	2650	119·3	118·1	860	40·1	41·7	1	6
2	,,	Medium.	2650	120·6	119·4	910	41·2	40·4	1	6
3	Small village in Kincardineshire	,,	2830	122·5	113·7	890	36·5	36·6	2	0
4	Cupar Fife	,,	2740	128·5	123·1	850	40·4	42·5	1	10
5	Inverness	Large	2760	122·3	116·3	760	39·3	46·1	2	2
6	,,	Medium.	2840	118·7	109·7	910	41·2	40·4	1	8
7	Banff	,,	2710	120·0	116·6	940	47·4	45·0	1	6
8	,,	,,	2800	122·4	114·7	810	36·1	39·8	1	1
9	Dundee	Large	2590	120·7	122·3	870	41·2	42·3	2	2
10	,,	Medium	2740	119·7	114·7	910	35·7	35·0	1	6
11	Glasgow	Large	2730	103.6	99·6	810	45·2	49·8	2	2
12	,,	Medium	2520	116·4	121·3	880	36·5	37·1	2	4
13	,,	Low	2600	116·7	117·9	950	42·5	39·9	2	2
14	Edinburgh	Medium	2520	119·4	124·4	870	42·3	43·4	2	4
15	,,	Large.	2600	135·7	137·1	910	40·5	39·8	2	6
16	,,	Low.	2790	128·9	121·3	860	32·5	33·7	2	0
17	Airdrie	Medium	2750	141·6	135·2	860	43·2	44·9	2	0
18	,,	,,	2800	121·8	114·2	920	41·3	40·1	2	6
19	Greenock	,,	2320	120·4	136·2	810	53·8	59·3	1	10
20	,,	Large	2440	121·5	130·7	800	40·9	45·7	2	8
21	Dumfries	Medium	2580	120·5	122·6	940	45·7	43·4	2	0
22	,,	,,	2490	127·6	134·5	920	41·6	40·4	2	0
	England.									
23	Carlisle	Medium	2590	112·9	114·5	890	39·3	39·5	2	0
24	,,	,,	2810	102·1	95·4	965	40·7	37·7	2	0
25	Lancaster	,,	2560	121·6	124·7	825	41·0	44·4	1	8
26	,,	,,	2730	120·7	116·6	820	39·9	43·4	1	10
27	Preston	Low	2700	116·9	113·7	920	35·2	34·2	2	0
28	,,	Large	2560	118·3	121·3	920	56·1	54·4	2	6
	Manchester:									
29	City	,,	2590	121·6	123·3	885	38·3	38·7	2	9
30	,,	,,	2660	123·2	121·6	1020	39·8	34·8	2	8
31	,,	,,	2750	135·9	129·7	910	41·8	41·0	2	8
32	,,	Medium	2360	118·3	131·6	900	39·9	39·6	2	4
33	,,	Large	2670	115·3	113·4	870	37·8	38·8	2	9
34	Oxford-street	Medium	2650	114·1	113·0	900	40·9	40·6	2	9
35	,, ,,	Large	2630	119·0	118·8	940	40·4	38·3	2	9
36	Didsbury	Medium	2610	119·8	120·5	965	42·1	39·0	2	6
37	Strangeways	,,	2700	113·0	109·8	830	38·7	41·7	2	0
38	,,	,,	2800	121·8	114·2	870	40·8	41·8	1	0
39	Lower Broughton	,,	2400	116·6	127·5	840	38·3	40·7	2	4
40	Deansgate	Low	2520	104·2	108·5	1190	45·6	34·2	1	6
41	Gt. Ancoats-st.	,,	2630	119·1	118·9	860	40·4	42·0	2	0
42	Ardwick	,,	2300	117·8	134·4	860	57·2	59·3	1	6
43	Pendleton	Medium	2690	120·8	117·9	820	44·0	47·9	2	2
44	,,	,,	2720	117·8	113·6	900	40·1	39·8	2	6
45	Patricroft	Low	2560	107·6	110·3	930	45·4	43·6	2	0
46	,,	,,	2780	119·4	112·7	950	39·1	36·8	2	0
47	Eccles	Medium	2820	119·1	110·9	900	41·5	41·2	2	6
48	,,	Low	2620	126·7	126·9	960	39·9	37·1	1	8
49	Stretford-road	Medium	2590	123·0	124·8	900	46·0	45·7	2	4
50	Stretford	,,	2440	116·5	125·4	950	41·5	39·0	2	0
51	,,	,,	2620	120·0	120·5	830	42·3	45·4	1	9
52	Bowdon	,,	2590	110·9	112·4	840	28·6	30·4	2	3
53	,,	,,	2600	114·9	116·0	990	39·7	35·8	2	6
54	Altrincham	Low	2550	104·8	107·9	810	8·1	8·9	2	0
55	,,	Medium	2660	126·1	124·4	800	45·3	50·6	2	0
56	Southport	,,	2670	122·8	120·8	940	38·2	36·3	2	6
57	,,	Low	2670	99·9	98·2	960	22·6	21·0	1	6
58	Blackpool	Medium	2520	120·9	126·0	890	41·7	41·8	2	2
59	,,	,,	2560	116·7	119·7	955	42·5	39·8	2	2
60	Oldham	Low	2620	60·5	60·6	985	31·8	28·8	1	4
61	Ashton-under-Lyne	Medium	2720	122·1	117·9	900	39·4	39·1	2	0
62	Warrington	,,	2820	125·8	117·1	850	38·9	40·9	1	9
63	,,	,,	2940	119·1	106·3	960	38·3	35·6	2	0
64	Nantwich	,,	2680	119·5	117·1	890	39·6	39·8	1	10
65	Derby	,,	2810	120·3	112·4	980	39·8	36·3	1	6
66	,,	Large	2710	121·1	117·3	840	41·9	44·6	2	2
67	Loughborough	,,	2550	116·3	119·7	880	38·6	39·1	1	6
68	,,	Medium	2690	44·2	43·1	930	39·9	38·3	1	1
69	Nottingham	,,	2640	128·8	128·1	890	39·6	39·8	1	4
70	,,	Large	2690	122·4	119·4	850	40·0	42·0	1	0
71	Kegworth	Small	2530	116·9	121·3	910	40·2	39·4	2	9
72	Chesterfield	Medium	2640	117·7	117·1	920	36·9	35·8	1	9
73	Birmingham	Large	2580	119·5	121·5	810	39·8	43·9	2	2
74	,,	Low	2520	115·7	120·5	900	38·0	37·7	1	6
75	Norwich	,,	2490	114·5	120·8	890	38·2	38·3	1	9
76	,,	Large	2620	121·6	121·8	930	41·3	39·6	2	4
77	London	,,	2660	118·4	116·8	940	39·7	37·7	2	9
78	,,	Low	2580	101·6	103·4	870	41·5	42·6	0	9
79	Weymouth	Medium	2550	123·7	127·3	860	40·6	42·2	2	0
80	,,	Large	2660	117·0	115·5	910	39·2	38·5	2	0
81	Liskeard, Cornwall.	Medium	2610	104·0	104·6	850	43·3	45·4	1	8

(The figures given in the above table show the amounts of Anhydrous Potassium Iodide in the mixture, and of Zinc Sulphate, containing 7 molecules of water of crystallization in the lotion.)

It might be well to mention here with regard to the verification of these figures, that the analysis of each sample which deviated beyond five grains in the potassium iodide, or zinc sulphate, from the prescribed amount, was repeated, and the result, of the second analyses found in each case to agree with that of the first. The specific gravities of all the lotions closely coincided with the amounts of zinc sulphate found, but in the mixtures, owing to the different amounts of spirit of chloroform which had been added, on the one hand, and the difference in the actual composition of that spirit of chloroform on the other, the specific gravity was no indication to the quantity of potassium iodide present. In looking over the above table it will be seen that only two druggists out of the eighty-one have given exactly the required weight of potassium iodide; thirty-four have given *more* than the prescribed amount, and forty-five *less;* but it may be of further interest to notice that when the whole of the quantities of potassium iodide given by the eighty-one different druggists are added together that the total quantity comes to 220½ grains *less* than it would have been if each druggist had dispensed the exact quantity. Again, in the lotion, only one druggist out of the eighty-one gave the exact weight of zinc sulphate; forty-three have given *more* than the prescribed amount, and thirty-seven *less*; and when the whole of the quantities of the zinc sulphate given by the eighty-one different druggists are added together it comes to only 12½ grains *more* than it would have been if each druggist had dispensed the exact quantity. This *résumé* seems to show that a larger percentage of druggists have given less weight for the more expensive drug, viz., potassium iodide, than for the zinc sulphate, the value of which is infinitesimally small, but still, no one can come to the conclusion that this is really done with dishonest intention in the large majority of cases.

I think, however, that no one can have a doubt about the want of care which is shown generally in dispensing, by the above table. A large percentage have dispensed within a range of accuracy which many might consider reasonable. I have, however, made all my estimations with analytical accuracy, and I think it must be left to the medical profession to decide what limits of error they consider might be allowed. With the view to decide what amount of inaccuracy a pharmacist would consider allowable, I consulted a gentleman who is a partner in an establishment which does a considerable business in dispensing. After informing him of the investigation I had been making, I asked him what amount of inaccuracy he would consider allowable in dispensing 120 grains of potassium iodide in 6 ounces of fluid, and also for 40 grains of zinc sulphate in 2 ounces of fluid; he considered that in both cases they ought to be absolutely accurate, but if I allowed three-tenths of a grain either way I should be allowing sufficient for all practical purposes. I have, however, been still more lenient than my pharmaceutical friend, and have allowed five-tenths of a grain on either side of the prescribed quantity as the range of practical accuracy. I know that many dispensers will take objection to this range of inaccuracy as impracticable. We, as analysts, can weigh easily to the one-hundredth part of a grain, and I know that balances used by dispensers for weighing such quantities as 120 grains are capable of turning with the tenth part of a grain if kept in good condition, and I think under such circumstances it would be absurd for any one to contend that it is impracticable to weigh drugs within half a grain on these premises. I have formed the following summaries of the above results:—For the potassium iodide mixture, two druggists out of the eighty-one have given the exact weight prescribed; nine out of the eighty-one have come within the practical

range of accuracy; fifty-five out of the eighty-one have weighed within 5 grains either way of the prescribed amount; whilst the remaining twenty-six have made greater errors. For the zinc sulphate lotion, one druggist out of the eighty-one gave the exact weight prescribed; nineteen out of the eighty-one have come within the practical range of accuracy; fifty-one out of the eighty-one have weighed within 2 grains either way of the prescribed amount; whilst the remaining thirty have made greater errors.

In the actual measuring of the fluids, I have assumed that measurements within 5 fluid grains either way are absolutely correct, whilst those within 15 grains either way are practically correct.

For the potassium iodide mixture, six dispensers out of the eighty-one have measured correctly; eleven out of the eighty-one have come within the range of practical accuracy; thirty-two have measured within 50 grains (a teaspoonful) of the prescribed amount; whilst the remaining forty-nine have made greater inaccuracies. For the zinc sulphate lotion, six dispensers out of the eighty-one have measured correctly; sixteen have measured within the range of practical accuracy; twenty-eight have measured within 25 grains of the prescribed amount; whilst the remaining fifty-three have made greater inaccuracies. Lastly, with respect to the strength of the solution, some dispensers may make both their weighings and measurements in excess or deficiency, and in either case the strength might be exactly what is required; whilst others may have weighed correctly and measured incorrectly, or *vice versâ*, and in these instances, the strength of the solution, which is the most important point, would be wrong. The following shows the amount of deviation made in this respect:

Not one dispenser has succeeded in making the prescription to the exact strength in either the mixture or lotion.

In the potassium iodide mixture, five out of the eighty-one dispensers have come within the range of ½ a grain more or less than the prescribed amount; forty have made the strength of the mixture within 5 grains more or less than the prescribed amount; whilst the remaining forty-one have made greater errors.

In the zinc sulphate lotion fourteen out of the eighty-one dispensers have come within the range of ½ a grain more or less than the prescribed amount; forty-five have made the strength of the lotion within 2 grains more or less than the prescribed amount; whilst the remaining thirty-six have made greater errors.

It may be interesting, before leaving this part of the subject, to make a few further observations on the dispensing of these solutions. We found that the mixture of No. 74, dispensed by a man in Birmingham, was strongly alkaline to test paper, and I submitted its contents to further analysis and found, that out of the 115·7 grains represented in the table, 100·1 was composed of carbonate of potash, and 15·6 of iodide of potassium, etc. From this large proportion, it seems as if the former salt had been intentionally added, along with a small proportion of potassium iodide. One (No. 48) from Eccles contained 2·5 grains of Potassium Carbonate in the 126·7 grains weighed out. Many were absolutely free from Potassium Carbonate and many contained traces of that salt. No. 46 had both the mixture and lotion corked with very dirty corks. The dispenser of No. 16 (from Edinburgh) put in a preparation of orange

instead of spirit of chloroform. No. 4 (from Cupar Fife) added the spirit in such proportion that it possessed the smell of whisky; whilst No. 18 (from Airdrie) dispensed the chloroform without any spirit, so that it remained insoluble at the bottom of the bottle. This error might have proved serious if the last dose in the bottle, containing all the chloroform, had been swallowed by the patient. The seven mixtures to which the following numbers relate contained disagreeable looking sediments—17, 24, 45, 46, 56, 74, and 78. One more potassium iodide prescription was made to contain the same quantity of salt as the others, but the solution made up to two instead of six ounces. The following shows the result:—

TABLE II.

POTASSIUM IODIDE PRESCRIPTION.

No.	District.	Description of shop	*Actual measure* of the mixture dispensed. (In fluid grains.)	*Actual amount* of Potassium Iodide weighed out by the Druggist.	*Strength* of the mixture calculated on the two ounces.	Price.
The mixture as prescribed.			875	120 grs.	120 grs.	*s.* *d.*
1	Manchester: Stretford-road		895	123·1	120·4	1 2

With the view to test further the range of inaccuracies in other and more valuable medicines, Dr. Sinclair and I arranged to have a few different prescriptions dispensed, and he accordingly wrote out five, having the following composition:—

℞. Argent. Nitrat. ..... ℥ j
Aq. Distillat..... ℥ j
M. Fiat lotio. To be kept from the light.

These were subject to analysis, and the following Table shows the results:—

Table III.

Silver Nitrate Prescription.

No.	District.	Description of shop.	*Actual measure* of the lotion dispensed. (In fluid grains.)	*Actual amount* of Silver Nitrate weighed out by the Druggist.	*Strength* of the lotion calculated on 447·5 gr.	Price.
The lotion as prescribed.			447·5	60·0	60·0	*s.* *d.*
	Manchester:					
1	Moss Lane W.		410	59·8	65·3	1 0
2	do. London-rd.	Low.	425	44·8	47·2	1 0
3	do. Oxford-st...		425	57·4	60·4	1 6
	Liverpool:					
4	Gt. Homer-st..	Low.	433	73·2	75·6	1 4
5	London, E.C....		365	59·0	72·3	0 8

The figures in this table show the amounts of anhydrous silver nitrate contained in the solution.

These show that not one of them has given the weight of this drug accurately; one came within the range of practical accuracy; three came within the range of 5 grains, and two made inaccuracies of upwards of 13 grains. In measuring, none came within the range of absolute accuracy, viz., 5 grains either way, and only one came within the range of practical accuracy. In strength, one came within the range of practical accuracy, the others made errors of over 5 grains.

The next prescription was the following :—

℞. Quin. Sulphat. ..... ℥ j
Acid. Hydrochlor. dil..... ℥ j
Aq.....ad. ℥ ij

M. Sig. One teaspoonful to be taken in a wineglass of water twice a day.

Two of these prescriptions were dispensed, and three more containing the same amounts of quinine sulphate and hydrochloric acid, but made up to 6 instead of 2 ounces measure.

These were submitted to analysis, with the following results:—

Table IV.

Quinine Sulphate Prescriptions.

No.	District.	Description of shop.	*Actual measure* of the mixture dispensed. (In fluid grains.)	*Actual amount* of Quinine Sulphate weighed out by the Druggist.	*Strength* of the mixture calculated on the two ounces.	Price.
The mixture as prescribed.			875	60 grs.	60 grs.	*s.* *d.*
1	Liverpool: Lime Street		920	59·7	56·8	3 6
2	London, E.C.	Low.	900	42·0	40·6	2 6

In No. 2, the hydrochloric acid of the prescription had not been introduced, and most of the quinine sulphate remained undissolved.

No.	District.	Description of shop.	*Actual measure* of the mixture dispensed. (In fluid grains.)	*Actual amount* of Quinine Sulphate weighed out by the Druggist.	*Strength* of the mixture calculated on the six ounces.	Price.
The mixture as prescribed.			2625	60 grs.	60 grs.	*s.* *d.*
3	L'ncaster, Town		2660	56·8	56·1	3 0
4	Manch. Lnd.-rd.		2700	64·5	62·7	1 6
5	Liverp'l, Bootle		2810	59·7	55·8	2 2

The figures in these two tables represent the amounts of Quinine Sulphate containing 7 molecules of water of crystallization.

In this it will be noticed that in the quantities weighed none of the five dispensers arrived at absolute accuracy, two came within the range of practical accuracy, and the remaining three are outside this mark; none measured within the range of either absolute or practical accuracy, and none came within the range of either absolute or practical accuracy in the strength of their solution.

The third and last prescription was the following:—

℞. Ferri et Quin. Citrat..... ʒij
Aq..... ℥vj
Sig. ℥ss, ter die.

Two of these prescriptions were dispensed, and one containing the same amount of salt, but made up to 2 instead of 6 ounces.

The results of the analysis are as follows:—

TABLE V.

IRON AND QUININE CITRATE PRESCRIPTIONS.

No	District.	Description of shop.	*Actual measure* of the mixture dispensed (In fluid grains.)	*Actual amount* of Quinine and Iron Citrate weighed out by Druggist.	*Strength* of the mixture caclulated on the 2690 grains.	Price.
The mixture as prescribed.			2690	120 grs.	120 grs.	*s. d.*
1	Manchester: Hulme.		2690	122	122	1 6
2	London, E C.		2570	140	146·5	1 9

No.	District.	Description of shop.	*Actual measure* of the mixture dispensed (In fluid grains.)	*Actual amount* of Quinine and Iron Citrate weighed out by Druggist.	*Strength* of the mixture calculated on the 940 grains.	Price.
The mixture as prescribed.			940	120	120	*s. d.*
3	Manchester: Oxford.road.		985	107	102·1	2 6

The figures in these tables represent the dry iron and quinine citrate, plus 10·5 per cent, the amount which we found the salt to lose on drying at 212° F.

Not one of these three came within the range of absolute or practical accuracy in either the weight or the strength of solution. One, however, measured with absolute accuracy,

the remaining two were out of the range of practical accuracy in every respect.

In concluding, it may be of some importance to mention that in the dispensing of these prescriptions, in the large majority of cases, and generally in the more respectable shops, no questions were asked of the purchasers, and no remarks made, but in some cases, and especially in those shops of a lower class, questions of rather an impertinent nature were asked ; in one, not only was the patient's name demanded, but the name of the medical man who prescribed; and in another instance the druggist actually refused to dispense a prescription containing 10 grains doses of quinine sulphate on the ground that the dose was excessive, and one who did dispense it remarked that the dose was a strong one. The bearing of these facts on the relative position of the physician, patient, and druggists, although of much importance, especially to the medical profession, does not come within the scope of my paper.

In conclusion I must express my best thanks to our assistant, Mr. Percy J. Winser, for the painstaking and accurate manner in which he had helped me in this investigation

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MICROSCOPICAL AND NATURAL HISTORY SECTION.

February 14th, 1876.

CHARLES BAILEY, Esq., in the Chair.

Mr. E. W. Nix, M.A., was elected a Member, and Dr. John Roberts an Associate of the Section.

Mr. Percival, through Mr. Rogers, exhibited specimens of a new British moss—Hypnum nitidulum (Wahl), belonging to the sub-genus Plagiothecium—found by him and Mr. Whitehead on June 8th, 1868, at Penneghant Gill, Craven,

Yorkshire. It differs from its near ally, H. pulchellum (Dicks), in its leaves being broader and larger, and in the male flowers being separate and distinct. Besides, H. nitidulum affects rotten wood, decayed bark, or decomposed vegetable matters as a site for its growth; whilst H. pulchellum always grows in the fissures of rocks.

Mr. Plant exhibited a rare hydrocarbon mineral from peat found near Manchester, The mineral crystals which encrust and radiate over the inner surface of the pine bark in the specimen exhibited, belong to the Fichtelite group of the hydrocarbons, and may be subsequently determinable to this. If so, it will be the first instance of Fichtelite having been recorded as occurring in Great Britain.

Mr. Plant then read a paper on the gradual decrease of wild birds during the last 25 years west of Manchester. The list included all the birds—residents, visitants, and casual stragglers—observed in and near to Peel Park, in the years 1850-60-70, and the numbers resident in 1871-75.

The birds recorded in 1850 were 71; 1860, 42; 1870, 19; and in the last five years only 8 resident birds were to be found.

The causes for the decrease were chiefly increase of building, destruction of trees from many causes, and general absence of food and shelter for birds.

Ordinary Meeting, March 21st, 1876.

EDWARD SCHUNCK, PH.D., F.R.S., &c., President, in the Chair.

Dr. Arthur Schuster exhibited an interesting collection of objects brought by him from Siam and the Western Himalayas.

"On a Graphical Method of Drawing Spectra," by Mr. WILLIAM DODGSON, Whitworth Scholar. Communicated by Professor ROSCOE, F.R.S., &c.

Construction of Curve for ascertaining the wave-lengths.

A number of points are first plotted on the curve-paper, the abscissæ of these points being the micrometer scale-readings of certain lines, as observed directly in the spectroscope, or being absolute—or relative measurements taken from an existing photograph; whilst the ordinates of these points are the corresponding wave-lengths, taken from the determinations of some reliable observer.

If there be a large number of points taken, the curve ought not to be drawn actually through them all, or it would probably be irregular; it therefore becomes necessary to draw a mean curve, *i.e.*, a continuous even curve which shall pass near to all the given points, some being on one side and some on the other.

The following method was employed to determine the wave-lengths of the well defined edges of the bands in two absorption spectra.

The micrometer scale readings of 27 air-lines were observed in the spectroscope, in addition to those of the absorbing vapour, and taken as abscissa; and the corresponding wave-lengths determined by Thalén as ordinates. These 27 points when plotted on the curve-paper, fell naturally into six groups; a mean point was then found for each group by accurate measurement, and the curve drawn through these

six mean points, such that the sum of the shortest distances of the several points of any one group from the curve is zero.

The mean points were obtained by means of the arrangement shown in Fig. 1.

The wooden rod AA has a steel point CC fixed at one end, and a graduated scale of tenths of an inch at the other; the axis of the steel point is kept vertical and the scale horizontal while the rod is being rotated, by the strip of wood TTP, the end P sliding on the table. The centre C being placed at some fixed point, the curve-paper is then adjusted on the table, so that some particular division on the scale (found by trial) describes a circle through a group of points, and also through two adjacent groups, one on each side, which circle if drawn would pass not far from the mean points of the three groups we are proceeding to determine. The distance from each point of the middle group to the centre C is then read off on the scale to the $\frac{1}{100}$th of an an inch, with the aid of a lens, and a second scale divided into $\frac{1}{100}$ths of an inch; and a point plotted near the centre of gravity of the middle group at a distance from C equal to the mean of these readings.

This process is repeated for each of the four middle groups, the mean points of an end group being determined with the paper and centre C in the same positions as for the second group from that end.

A nearer approximation to the true position of the mean points may then be found, by making use of those already obtained, to find more correctly the radius of the circle through the three groups, and repeating the process of measuring and plotting.

In one case an isolated point occurs; this is taken as one group, and the curve drawn through it.

The curve consists of arcs of circles, which pass through the six mean points, with radii varying from $64\frac{1}{4}$ inches at the upper end, to $61\frac{1}{2}$ inches at the lower end, drawn by means of the rod AA, having a drawing pen fixed to it.

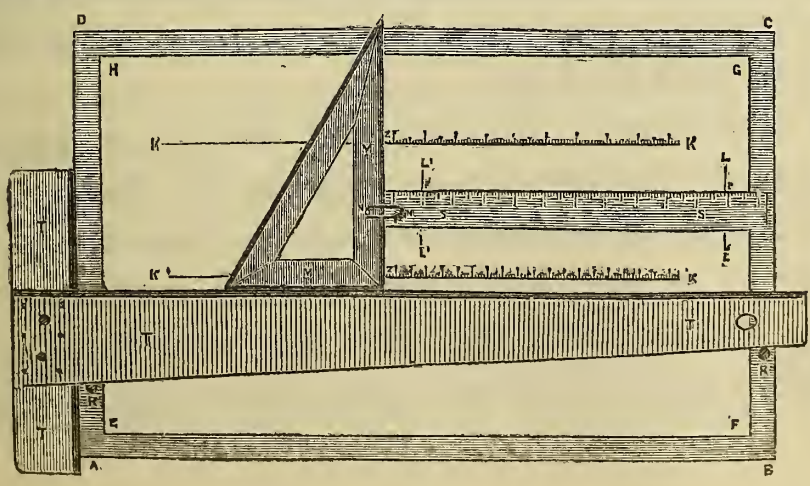
The wave-lengths corresponding to the scale-readings of the observed lines in the two spectra, were then found by measurement from the curve to $\frac{1}{1000}$th of an inch, by means of a lens, and scale of $\frac{1}{100}$ths of an inch.

The above method of graphically drawing a curve, may be extended to the case where the points are nearly uniformly distributed, and not divided into groups naturally as in the case of the air-lines.

Divide the points into any number of groups, about an equal number in each group. Find the mean points as described, by aid of lens and vernier scale on the rod; draw the curve through the points by the best practical method. The number of groups taken will be guided by judgment, and will depend on what degree the proposed curve shall be. The greater the number of groups, the greater will be the degree of the equation to a curve passing through their mean points, and the greater probably will be the irregularities in the variation of the radius of curvature.

Construction of Scale for Map of Spectrum.

The arrangement shown in Fig. 2 has been employed to draw the map scale, and found to be an accurate and expeditious method.



ABCD the drawing board, EFGH the drawing paper, TT Stanley's ebony-edged T-square, resting against the pins RR during the operation; MM Stanley's ebony-edged set-square, which slides along the edge of TT; SS Stanley's engine-divided, millimetre scale, connected at one end to the edge of the set-square M, by pins and elastic string NN, so as to slide with the set-square, and have its graduated edge parallel to the edge of TT, and also parallel to the lines KK, K′K′ on which the scales have to be constructed; LL a very fine ink line at right angles to the edge of the scale, beyond the extremity of the required scale KK, on the right hand side, to which the divisions of the millimetre scale are adjusted by the eye, with the aid of a lens placed on a stand, its axis in a vertical plane through the line LL; a fine adjustment of the line and division is obtained by means of the blunt handle of the drawing pin, used as a lever against the end of the scale, the surface of the board or the paper being the fulcrum.

The divisions of the map scale are drawn at Z,Z, with a very thin drawing pen, very close to the edge of the set square, so that the variation of the inclination of the drawing pen is a very inappreciable error. If the map scale is required to be longer than the scale S, another very fine perpendicular ink line L′L′ must be drawn at an exact multiple of 10 millimetres distant.

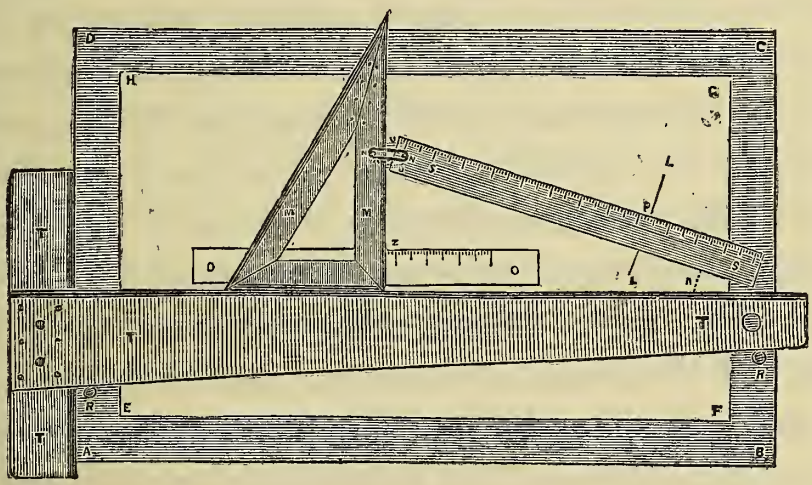
To prevent mistakes in drawing the principal divisions, the line LL is arranged so that they may be drawn when the corresponding principal divisions on the scale SS are coincident with the line.

The advantages of this method of drawing a map scale, arise from the fact that the error due to the observation of the coincidence of two lines, is much less than that of plotting a point opposite each division of the millimetre scale. Also in the fact that the error due to drawing a line with a thin pen very close to the edge of the set-square,

(the pen approximately at the same inclination) is much less than that of drawing the divisions through the plotted points, judging by the eye.

If only one scale be required on the map, place the edge of the scale S near to the line KK. If two are required, place the edge of SS half-way between KK, K′K′ to lessen the errors due to imperfections in the straight edge of the T-square.

Construction of a Vernier Scale for the above Map Scale.



The drawing board, T-square, set-square, and paper as in Fig. 2. OO a strip of paper, on which the vernier scale is to be constructed, its edge being parallel to TT, the scale SS is attached to the edge of the set-square and slides with it, by means of the pins and elastic NN as before, but inclined to the edge of TT at an angle $\alpha = \sec.^{-1} \frac{21}{20}$; it is kept in this position by the pegs U, U in the end of the scale; the fine ink line LL is drawn at right angles to SS, the lens being used on a stand as before, with its axis always in a vertical plane through LL.

The divisions on the vernier scale will be $1\frac{1}{20}$ millimetres in length.

"Evidence to prove that a Bone from the Windy Knoll, Castleton, named by Professor W. Boyd Dawkins, F.R.S.,

'Sacrum of young Bison,' is a Sacral Bone of the Cave Bear, *Ursus Spelœus*," by JOHN PLANT, F.G.S.

When I first described, at the Manchester Geological Society in April, 1874, a number of bones which came from a limestone fissure near Castleton, they were correctly attributed, even upon a cursory examination, to be the remains of Bison, Reindeer, Wolf, and Bear, the bulk of them belonging to the Bison. In the course of a careful examination subsequently, several of the bones were found, presenting characters not to be determined by the aid only of such scanty help for comparison which was at my service, so I took a number of them to the Liverpool Museum, and, with the kind assistance of Mr. Moore, the Curator, was able to compare them with skeletons of bovine and ursine animals, as well as with a collection of bones of the Cave Bear —*U. Spelœus*— which the Museum possessed, from La Grotte des Echelles, France. Some of my specimens could not be determined then, and have not yet been identified; but in one case both Mr. Moore and myself were quite of the opinion that it bore a close resemblance to a sacral bone of the Cave Bear, in their collection from La Grotte des Echelles, and I ventured without hesitation to ascribe it to that animal.

At a meeting of the Geological Society in May, 1874, I specially exhibited this bone, and described the new interest which had become attached to it. Professor Dawkins, however, expressed his doubts as to the correctness of my naming, and I at once placed the bone in his hands so that he could satisfy himself upon the matter. A month after (June 24) I received the bone, with a short note saying;— "*The bone which I have ordered to be returned is sacrum of young Bison,*" and upon the bone itself was written, "*Bison, W.B.D.*"

Surprised, but not convinced, I paid another visit to the Liverpool Museum, and with my friend Mr. Moore recom-

pared this identical bone with the sacral bones of all the bovine skeletons in the Museum, and from merely having an opinion, I became positively certain of my first determination of the bone, and equally certain that my specimen did not, and could not, belong to a bovine animal.

In the Proceedings of the Literary and Philosophical Society of Manchester, October 6th, 1874, p. 6, Professor Dawkins states—"The Cave Bear, or *Ursus Spelœus*, is also stated by Mr. Plant (Manchester Geological Transactions, xiii, 130—156) to have been discovered in the Windy Knoll fissure, principally on the *fancied resemblance* which a sacrum of a young animal bore to a sacrum in the Peel Park Museum, *said to belong to Ursus Spelœus*, partly also on the stumps of two teeth, worthless for purposes of specific identification. *I have carefully analysed this evidence, and on comparing the sacrum in question with that of the ox and bear, I believe that it belongs to a young bison, and not to any carnivora.* And, further, even if it belong to a bear, there is no evidence as to the species, because the specific characters of that bone in the fossil bears have not yet been ascertained. The researches of Professor Busk, during a long series of years, and my examination of the most important collections of fossil bears in this country and in France, prove that the determination of the species is a point of extreme difficulty, and we are only able to detect characters of specific value in the heads and dentition. On this point I would refer to Professor Busk's memoir, and to the vast collection at Toulouse. The Cave Bear, therefore, of Windy Knoll must be given up, as being based on a faulty determination."

It was a great surprise to me to find Professor Dawkins deliberately stating "that he had compared my specimens with the sacral bones of the ox and bear, and that it belonged to a young bison and not to any carnivora." I am aware that he is credited with the possession of great

experience and knowledge in the bones of Pleistocene animals, and must know the risks of damaging that reputation in giving an opinion upon a matter like this without full consideration; but as he had the bone in his possession for nearly one month, it could not be said he formed his opinion in a hasty manner.

Notwithstanding this deliberately expressed opinion of Professor Dawkins that it belonged to a young bison, I was not alarmed for my small reputation as a palæontologist, or convinced that he was right. I had myself seen and examined sacral bones of both oxen and bears, and always found the differences between them far too striking to be mistaken. I was sure this bone could never be bovine, and I had a firm opinion that it was Cave Bear; moreover, I considered that nature could never be so hard up for variety as to give to the stiff-backed oxen tribe a sacrum that could be confounded with the sacrum of the lithe and flexible hindquarters of the bears.

However, I set myself to the study of bears and oxen, took the bone with me whenever I had a chance of comparing it with bones in public museums and private collections, and sent it for examination and report to gentlemen, who have made comparative osteology their special study, and without exception the opinions I received were unanimous in one respect, that it was not the sacrum of a bison, or even of a bovine animal—but the *sacrum of a bear.*

It is not necessary, nor do I intend, to mention the names of gentlemen to whom I here allude; their opinions were formed pretty much like my own by direct comparison only, without going into the minute anatomical points of the differences of structure between sacral bones of bovines and ursines. Comparison is usually a safe method of determining species in natural history, and it applies with equal force with bones, or portions of bones, when authenticated specimens can be obtained for comparison.

Being in London in February, I waited upon Professor Owen, at the British Museum, and submitted the bone to his experienced judgment. He most kindly undertook to make a thorough examination of the bone, and give me his opinion. A few days after I called upon him again, when he took great pains to show me a number of sacral bones of bears and bison, and point out the clear differences between them in certain points, and in what way it could be proved that my specimen belonged to the bear and not to the bison, at the same time giving me the results of his determination in writing, with full permission to use it in any way that would serve the purpose of my enquiry.

"British Museum, 8*th February*, 1876.

"The fore end of the sacrum yields the best and readiest characters for distinguishing that of an ox from that of a bear. In the *Ruminant* the pre-zygapophyses present each a long longitudinal semi-cylindric channel, for the corresponding convexity of the post-zygapophyses of the last lumbar vertebra.

"In the *Bear* the pre-zygapophyses of the first sacral, present a short suboval flat, or almost flat, surface, which becomes slightly concave below through the production of the mesial border of the process.

"In the Ox the symphysial surface for the ilium is in great part presented by the transverse process of the first sacral, which is much produced, these processes give a winged character to the fore part of the sacrum; the surface itself is long, narrow, and looks backward more than outward.

"In the Bear the transverse process of the first, is little longer than of the second, sacral, and it is much thicker in proportion to its length than in the Ox. The second sacral contributes a larger proportion to that surface than in the Ox.

"The neural spine of the first sacral in the Bovines is long (lofty), compressed, and becomes confluent with the second, as this with the succeeding sacral spines, to form a continuous bony crest.

"In Ursines the sacro-neural spine in the first vertebra is small and short; in the second often almost obsolete, that of the third sacral, though small and short, is usually better developed, but all remain distinct from each other, with well marked intervals, except along their base.

"No palæontologist who had ever made this comparison could risk the mistaking of a bear's sacrum for one of a bovine quadruped.

"RICHARD OWEN."

Before leaving Professor Owen I pointed out to him that the bone he had taken so much trouble to compare with the large series of specimens before him was marked "Bison, W.B.D.," and had been so named by Professor Dawkins, and I also informed him that it had previously been submitted to the care of Mr. Wm. Davies, acknowledged to be the most experienced comparative osteologist in the Zoological Department in the British Museum, and also to the assistant in this department, Mr. Gerrard (who has charge of the skeletons), who, although at first inclined to the opinion that the bone had the aspect of a bovine sacrum, after careful examination, agreed with his colleague Mr. Davies in his determination, which is this—"Undoubtedly the first and second sacral vertebræ of the Cave Bear, *Ursus Spelœus*.—WM. DAVIES."

The last remark of Professor Owen was that this opinion from Mr. Wm. Davies was quite sufficient in itself to have settled the question of the species of the bone. His own remarks had been solely directed to explain the marked differences between the sacral bones of oxen and bears.

The drawings I exhibit to assist in showing the special points alluded to by Professor Owen, the specimens of sacral vertebræ of oxen, bison, and the sacrum of Cave Bear from the Liverpool Museum, to compare with the sacrum from Castleton, will, I doubt not, be convincing, and prove beyond all doubt that the bone in question was at the first correctly described when I named it sacrum of *Ursus Spelœus*.

PHYSICAL AND MATHEMATICAL SECTION.

October 12th, 1875.

E. W. BINNEY, F.R.S., F.G.S., President of the Section, in the chair.

"On a Source of Atmospheric Ozone," by JOSEPH BAXENDELL, F.R.A.S.

The source of atmospheric ozone is a subject respecting which various opinions have been entertained by chemists and meteorologists. According to M. Schönbein, Mr. Dancer, M. Houzeau, Professor Roscoe, and others, it is due to electrical action. Dr. Daubeny, from a long series of experiments, was led to attribute it to the action of sunlight on the green leaves of plants. M. Gorup-Besanez believes it is simply the result of evaporation; and Mr. Mackereth regards it as being dependent on a peculiar and direct action of the sun's light upon the oxygen of the atmosphere.

In my paper "On Observations of Atmospheric Ozone," read October 20th, 1868, I stated that from my own observations it seemed probable that the amount of ozone near the earth's surface depended upon the height at which clouds are formed in the atmosphere. Subsequent observations confirmed this view, and also showed that the amount of ozone had, in general, some relation to the degree of transparency of the lower atmosphere. Thus when fogs and haze were prevalent it rarely happened that even the faintest trace of the presence of ozone could be obtained; but on their disappearance the indications became more marked, and in clear states of the air the test papers were generally more or less coloured. It appeared, therefore, from these results that atmospheric ozone was absorbed or

decomposed by haze or fog, and was given off or produced when evaporation changed haze or fog into invisible aqueous vapour.

From the very small degree of solubility of ozone in water it seems highly improbable that the amount of water existing in ordinary haze or fog could absorb the whole of the ozone usually found in the atmosphere, nor could the whole of this ozone be contained in the water from which the aqueous vapour in the air had been derived. Moreover, not only does haze prevent the coloration of the test papers, but it often rapidly bleaches those which had already been coloured by the action of ozone. This bleaching effect, however, is not produced if the papers are thoroughly wetted by immersion in water, and therefore it has been attributed to the action of a form of oxygen differing essentially in some of its properties from ozone, and which has, therefore, received the name of antozone.

The existence of antozone is, however, doubted by many chemists, and it becomes, therefore, necessary to seek some other explanation of the bleaching effect of fogs and haze, which will also, at the same time, account for their effect in apparently absorbing or decomposing ozone, and afterwards of giving it off or forming it on evaporation.

As it is generally supposed that the minute vesicles or globules of water which form fog and haze are similar in all respects, except perhaps in size, to the globules which form the spray from a breaking wave, a waterfall, or fountain, it was evidently desirable to ascertain whether the spray from any of these sources would produce effects similar to those produced by fog and haze, since it might be contended that as in the one case the globules were the result of a condensation of aqueous vapour taking place in the air, while in the other they were produced by a more or less violent mechanical action, their effects upon the oxygen or ozone in the atmosphere might be very different.

In 1872 I had a series of observations made twice daily for five weeks at stations on opposite sides of one of the reservoirs of the Manchester Corporation Waterworks, and, grouping the results according to the direction of the wind, I found that the mean values for the station on the lee side of the reservoir were not sensibly different from those at the station on the windward side. The surface of the water was, however, seldom sufficiently disturbed to produce any appreciable amount of spray; but the results of the observations clearly indicated that mere evaporation from a large continuous surface of water had no effect in increasing the amount of ozone in the air passing over it.

Observations and experiments made at Southport on the action of spray from the sea led to no satisfactory result on account of the difficulty of eliminating the effects due to varying velocities of the wind; but the influence of fogs and haze in checking the coloration of the test papers was very marked.

I had long been anxious to try the effects of spray from a large fountain, but had no opportunity of doing so until June last, when I became aware for the first time of the existence of the fine fountains at the Arnfield and Hollingworth reservoirs in the Manchester Corporation Waterworks' district. In both these fountains the diameter of the column of water as it issues from the discharge pipe is nine inches, and under full pressure the height of the column or jet is about 27 feet at Arnfield, and 35 feet at Hollingworth. The water is turned on at very irregular intervals, and generally for only short periods of time, but with the kind assistance of Mr. James Wilkins, the very intelligent reservoir-keeper, and observer at the Arnfield meteorological station, I succeeded in making a satisfactory series of experiments, the details of which are as follows :—

For the exposure of the test papers two open boxes were used, each about 2 feet long, 10 inches wide, and 4 inches

deep. These boxes were placed on end, one on the windward, the other on the leeward side of the fountain, and the test papers were pinned in the upper ends of the boxes, and the boxes so placed that the papers were not exposed to direct sunlight, nor to wind and rain.

The first experiments were made on June 16, 1875, and three of Schönbein's test papers were placed in each box and exposed from 9.30 a.m. to 1.30 p.m. At the Arnfield fountain the resulting tints were :—

In Windward. Box (W).	In Leeward. Box (L).
4·5	7·0
5·5	7·0
5·2	8·0
Mean = 5·07	Mean = 7·33

At the Hollingworth fountain they were :—

W.	L.
5·0	6·5
4·0	6·5
5·0	7·5
Mean = 4·67	Mean = 6·83

Fresh papers were exposed from 1.30 to 6.30 p.m. with the following results :—

ARNFIELD.

W.	L.
5·5	8·0
7·5	7·0
6·0	5·0
Mean = 6·33	6·67

The third paper in the L. box was evidently a faulty one.

HOLLINGWORTH.

W.	L.
5·0	6·5
4·0	6·5
4·0	6·0
Mean = 4·33	Mean = 6·33

And the mean results of the two experiments were:—

	W.	L.
Arnfield	5·7	7·0
Hollingworth ...	4·5	6·6

July 2 and 9.

Experiments were made on both these days, but the atmosphere was hazy and rain fell, and none of the papers were coloured.

July 10—ARNFIELD.

Three papers, exposed in each box from 2.20 to 7.20 p.m.; but at 4.45 it was noticed that the wind had changed and the boxes were removed into fresh positions. The height of the jet was only 11 feet. The tints were:—

W.	L.
5·0	4·2
4·5	6·0
4·5	5·5
Mean = 4·66	Mean = 5·23

July 11—ARNFIELD.

Three papers in each box exposed from 9.30 to 11.40 a.m.; height of jet about 16 feet; very cloudy, but the air pretty clear.

W.	L.
4·0	5·5
3·5	5·0
4·0	4·0+
3·83	4·83

At 11.50 a.m. one paper was left in each box, and at 4.50 p.m. the tints were—

W.	L.
3·5	5·0

The weather was showery, and the wind oscillated between W.S.W. and W.N.W.

At 7.0 p.m. two papers were left in each box, and at 8.0 the following morning one paper was taken from each box, and the shades of colour were found to be—

W.	L.
2·0	3·0

At nine a.m. the remaining papers were both No. 4.

July 15—ARNFIELD.

Three papers exposed in each box from 2.30 to 4.40 p.m.; height of column of water about 20 feet; wind blowing in strong breezes from E.N.E.; air pretty clear, but sky very cloudy. The results were :—

W.	L.
3·5	4·0
3·0	3·5
2·5	3·5
Mean = 3·00	Mean = 3·66

Fresh papers were exposed from 4.50 to 7.5 p.m., with the following results :—

W.	L.
4·0	4·0
3·5	4·5
3·5	5·5
Mean = 3·66	Mean = 4·66

At 9 p.m. two papers were left in each box, and at 5.0 the following morning the results were—

W.	L.
7·5	9·0
8·0	9·0
Mean = 7·75	Mean = 9·0

August 11—ARNFIELD.

Two papers in each box from 12.30 to 3.30 p.m.; height of jet about 16 feet; temperature of the air at 12.30, 70°.5; temperature of evaporation, 63°.0; wind, S.W. to W.S.W. in light breezes.

W.	L.
2·5	4·5
3·5	5·5
Mean = 3·00	Mean = 5·0

One paper in each box was afterwards exposed from 4.0 to 7.0 p.m., when it was observed that the air was becoming hazy.

W.	L.
2.0	3.0

August 12.

Two papers in each box from 12.0 to 4.0 p.m.; but the air was very hazy, and there was no action on any of the papers. A thunderstorm occurred between 4.0 and 6.0 p.m., and at 7.0 p.m. the papers were again examined, with the following results :—

W.	L.
0·0	1·0
0·0	2·5
Mean = 0·0	Mean = 1·75

August 13—ARNFIELD.

Two papers in each box from 1 to 2.30 p.m.; air pretty clear; light breeze from W.S.W.; jet 16 feet. The spray box L was 9 yards from the jet. The distance on former occasions had varied from 7 to 17 yards according to the strength of the wind.

W.	L.
1·0 (A)	3·0 (A)
3·5	5·0

The papers marked (A) had been in my pocket-book since the previous day, but the others were fresh from the ozone box. A thunderstorm occurred between 4 and 5 p.m.

August 14.

At 10 a.m. two papers were placed in each box; at 12 no action had taken place on any of them, the air being very hazy. At 2.15 p.m. the air had become much less hazy and the tints were—

W.	L.
0·0	2·0
0·0	2·0

The height of the jet of water on this occasion was 21 feet. At 2.15 p.m. the readings of the dry and wet bulb thermometers were :—Dry, 68°·5 ; Wet, 61°.7.

The experiments thus briefly described appear to me to prove that the spray from a fountain on evaporating gives off or produces atmospheric ozone, and in this respect is similar to ordinary fog or haze.

In some of the experiments which I made the papers in the leeward box became sensibly damp in consequence of the box being placed too near the fountain, or from the acting of strong gusts and eddies of wind. In these cases the coloration of the papers was very much retarded or altogether prevented, and it therefore appears that spray has, like fog or haze, the power of absorbing or decomposing atmospheric ozone.

Having now proved, experimentally, that spray produced by mechanical means, and ordinary fog or haze produced by the condensation of aqueous vapour in the air, are precisely similar in their relations to atmospheric ozone; and having also shown that the quantity of ozone usually found in the air could not have been held in solution by the water from which the aqueous vapour in the atmosphere is derived it becomes evident that the production of atmospheric ozone is in some way dependent upon the minute state of division in which water exists in the air in the visible form of clouds, fogs, and haze, and often also probably in an invisible form. This consideration has led me to infer that water exposed to the air has the power of condensing Oxygen upon its surface into a thin film of ozone. When, therefore, complete evaporation of the vesicles or globules of moisture which constitute a cloud or fog takes place the ozone is left free to diffuse itself through the air; but when evaporation takes place from the surface of a large and practically inexhaustible mass of water the ozone is not set free but remains adhering to the surface It will, however, be objected that if ozone is formed in this way test papers ought to be coloured very rapidly in a fog or dense haze, and that no bleaching action could take place upon papers which had already heen ozonised. The explanation which I will venture to offer is that ozone associated with moisture and in the presence of the oxydised potassium will combine with the freed iodine and form iodic acid which, uniting

with the potash, will form the colourless iodate of potash. But it may also be that the direct action of ozone on iodide of potassium is retarded or altogether prevented by an excess of moisture when the ozone is present in only small quantities as is usually the case in the atmosphere, and this view is supported by the fact that dry papers appear to be generally more sensitive than damp ones.

Admitting that the inference I have drawn from the facts given in this paper is correct, it will enable us to explain why, on the sea coast, winds from the sea bring more ozone than those from the land, and why, when the cloud stratum is high, the quantity of free ozone near the surface of the earth is, in general, greater than when the cloud level is low. It also indicates that the sudden and considerable manifestations of ozone which sometimes occur may be found to be due to descending currents bringing air from the cloud region to lower and warmer levels and thus causing the rapid evaporation of the condensed vapour which it contains. It may also enable us to trace out the causes of the differences which exist between the mean amounts of ozone in different localities, and will, I believe, be useful in suggesting new methods of treating meteorological observations and attempting the solution of some of the difficult but interesting problems which are at present engaging the attention of meteorologists.

February 29th, 1876.

E. W. Binney, F.R.S., F.G.S., President of the Section, in the chair.

"An Account of some early Experiments with Ozone, and remarks upon its Electrical Origin," by J. B. Dancer, F.R.A.S.

Nearly a century since it was noticed that oxygen gas, when electrical sparks had been passed through it, acquired a peculiar smell and the power of attacking mercury. Somewhat later it was found that electrified air possessed the property of purifying decomposing animal and vegetable matter. In 1826 Dr. John Davy believed this principle existed in the atmosphere, and proposed tests for its detection.

When residing in Liverpool in the year 1838 I supplied some Daniell's batteries to Mr. T. Spencer. The apparatus consisted of a number of cells, in which I had substituted* thin porous jars, made of unglazed biscuit ware, to separate the two fluids, in place of the bladders, and ox gullets, which were very disagreeable in use, and easily destroyed; these porous jars and cells are now in general use, not only in Daniell's, but also in Grove's, and other batteries in which two fluids are employed.

It was expected that this battery would exhibit considerable power, and an evening was fixed upon to try some experiments with it at Mr. Spencer's house. The parties present at these experiments were Mr. Spencer, the late Mr. John Wilson (teacher of chemistry at the Liverpool Mechanics' Institution), Mr. James Robinson (now of Dublin), and myself. The first experiment was the decomposition of water. A Faraday's voltameter, with large platinum electrodes, was connected with the battery, and the mixed gases, as they were evolved, were collected in a glass gas jar, of the capacity of 180 cubic inches. The gas jar was filled with water, and placed on the shelf of a pneumatic trough; a bent glass tube from the voltameter had its end placed under the open bottom of the jar. When the experiment had proceeded for a short time we noticed that a white cloud, or vapour, escaped from the bubbles of

* Page 229. First edition of Elements of Natural Philosophy, by Dr. Golding Bird. London, 1839.

the mixed gases as they burst at the surface of the water in the jar. This white cloud remained permanent, and its unexpected appearance gave rise to many conjectures. When the jar became filled with the oxygen and hydrogen, it was removed from the shelf for the purpose of refilling with water, in order to repeat the experiment. As the gases were displaced from the jar, we became aware of the presence of a powerful odour, so pungent as to produce coughing. This was a second surprise, and it led to considerable discussion. The prevailing opinion seemed to be that some impurity in the sulphuric acid, used in the voltameter, had caused the white cloud and the odour. On one point we were all agreed—the odour was identical with that produced during the excitement of a frictional electrical machine, and the novel phenomena we had witnessed were admitted to be worthy of investigation. On repeating the experiment a second time similar results were obtained, and the room was filled with the electrical odour; being manipulator, I probably inhaled more of this odour than the rest of the company, and my throat was in a state of irritation for several days. I constructed another battery of similar power to that already named, and repeated the experiment at my own house, taking the precaution to have carefully-prepared sulphuric acid in the voltameter. The white cloud and odour were produced just as in the first experiments.

It became clear, therefore, that impurity in the sulphuric acid was not the origin of either cloud or odour. I filled several bottles with these odorous gases, and tried some experiments, such as the solubility of the odorous substance in water, its alkaline and acid properties, &c. These experiments were named to many scientific friends, one of them, the late Dr. Brett, then a chemist of repute, a relative of Dr. Golding Bird, of London. Dr. Brett offered to join me in investigating the properties of this peculiar odorous body,

and it was agreed that we should commence experimenting as soon as leisure would permit. Business affairs, however, obliged me to leave the subject in abeyance.

In the year 1839 F. C. Schönbein, Professor of Chemistry at Basle, whilst decomposing water by a voltaic battery, noticed that an odorous substance was evolved along with the oxygen gas at the positive pole. The identity of this odour with that which usually accompanies lightning, and that which is produced by passing sparks from an electrical machine to pieces of platinum or gold, induced him to enter on an investigation to discover, if possible, the source and properties of this odorous body, to which he gave the name "Ozone." His discovery was announced in a memoir which he presented to the Academy of Munich in 1840. When an account of his experiments appeared in the scientific periodicals, I recognised under the name of ozone the odorous body which had surprised us during our experiments in 1838.

The announcement of Schönbein's discovery caused considerable excitement in the scientific world, and a large number of scientific men in this country, and on the Continent, commenced investigating the properties of this remarkable body. In this brief and imperfect notice I can only name a few of the experiments. Those who are interested in the history of ozone may consult Dr. C. Fox's exhaustive work on ozone and antozone.* In "Nature," March 5th and 12th, 1874, there is also a very interesting account of ozone, in an address delivered before the Royal Society of Edinburgh by Dr. Andrews, F.R.S., December, 1873.

What is ozone? This is a question not easily answered in a satisfactory manner. This body has been tortured in every conceivable way by a legion of able experimentalists for the last thirty years, and up to this moment scientific men are not all agreed upon this subject.

* Published by Churchill. 1873.

Ozone is formed by passing an electric current through air or oxygen gas. Schönbein discovered that it was also generated, during the slow oxidation of phosphorus, in moist air. Ozone is a powerful bleaching and oxidising agent, possessing the property of purifying decomposing animal and vegetable substances. It oxidises many of the metals, is insoluble in water, and in solutions of acids and alkalies. If breathed in a concentrated state, it has a powerful effect on the animal system. To test the presence of ozone in the atmosphere, Schönbein proposed the employment of slips of paper impregnated with iodide of potassium and starch. These are exposed to the atmosphere with certain precautions; if ozone is present, these papers become coloured, and the depth of colour is supposed to indicate the amount of ozone. Schönbein at first supposed that ozone was a new electro negative element, analogous to chlorine and bromine; afterwards he suspected it to be a constituent of nitrogen. His investigations were continued for many years, and, from certain experiments, he concluded that oxygen could exist in three distinct states. When electro negative it was ozone, when positive it was antozone, and when these two states were combined it became passive, or neutral oxygen.

There are some scientific men who do not think the existence of antozone is satisfactorily proved. The elaborate researches of Dr. Andrews and Professor Tait have added largely to our knowledge of the nature and properties of ozone. These gentlemen discovered that when oxygen gas has been ozonised by a discharge of the electric current the volume of gas was diminished—for example, 100 volumes of oxygen become reduced to about 92 volumes. If changed back again by the agency of heat, or otherwise, it becomes 100 volumes again. Sorét discovered that the oils of turpentine and cinnamon, being brought into contact with ozonised oxygen, the whole of the ozone was absorbed. He concluded that ozone was $1\frac{1}{2}$ times the density of

oxygen. At present the prevailing opinion is that ozone is an altered condition of oxygen, the molecular constitution being different to that of ordinary oxygen.

Is ozone which is produced by an electrical discharge through air, or oxygen gas, identical with that observed in the atmosphere?

Many eminent men of science doubted the existence of atmospheric ozone; it was thought that other active substances in the air had similar reactions to those exhibited by ozone. The careful experiments of Dr. Andrews, which were intended to settle this important question, appear to confirm in a satisfactory manner the original views of Schönbein.

Ozone presented itself to my view in such close union with electricity that I have been almost forced to believe in its electrical origin. I expected that it would be ultimately found that an unstable chemical union existed between electricity and oxygen in the ozonised state. Some very careful experiments by Dr. Andrews appear to show conclusively that such is not the case; he finds that ozone may be readily destroyed by agitating it strongly with fine fragments of glass. Dr. Andrews remarks that this experiment forms a new and closer link than any hitherto observed between a purely mechanical action and a chemical change. Probably the generation of ozone is constantly taking place in the higher regions of the atmosphere; the formation of clouds, rain, hail, snow, &c., developing free electricity, under conditions highly favourable for the conversion of oxygen into ozone. The amount thus produced would be vastly augmented by agencies in operation at certain portions of the earth's surface. Ozone is said to be abundant at sea. This might have been anticipated; the friction of the wind on the surface of the waves, and the conversion of water into aqueous vapour (a change of state which always developes an abundance of free electricity) produce conditions as favourable as those

which exist in the upper regions of the atmosphere.

In the Lake district the manifestations of ozone are considerable; again there are conditions somewhat similar to those already named.

On land the amount of ozone generated will vary considerably with the character of the surface of the earth. In localities where vegetation abounds ozone should exist in considerable quantity; there is the mechanical action of the air over the moist surfaces of the vegetation, and the formation of aqueous vapour; and if it be true, as stated, that the oxygen which is evolved by plants is in an ozonised condition, we should have an additional source for the production of this purifying agent.

Heavy storms of rain, hail, and snow are always accompanied by free electricity and a manifestation of ozone. The pleasant sensations experienced on breathing the atmosphere after heavy rain are, perhaps, not altogether due to the washing of the atmosphere, but in part produced by the ozone contained in it. Mr. Baxendell noticed that when the fountains at the Waterworks, Arnfield, were set in operation he found the manifestation of ozone greater than he had observed in severe thunderstorms. This I can quite imagine possible. In discharges of lightning the production of ozone would be confined to the locality of the flash, and the effect on the test paper would depend on its situation and the direction of the wind. A water fountain may be regarded as a hydro-electric machine,* the friction of the water issuing through the jets developing electrical action, materially assisted by the conversion of the spray into aqueous vapour. I would suggest that this fact should be prominently brought before municipal bodies, to induce them to erect fountains in all available places in large cities as sanitary agents. They might prove highly beneficial in crowded localities.

* Humboldt mentions in Cosmos, vol. 1, page 344, "That the negative electricity near high water falls is sufficiently intense to produce an effect on a delicate electrometer at a distance of 300 or 400 feet."

"Results of Rain Gauge Observations, made at Eccles, near Manchester, during the year 1875," by THOMAS MACKERETH, F.R.A.S., F.M.S.

The rainfall of last year was above the average, by a little over the amount which fell in July above the average for that month. Hence it may be said that the excess of rainfall for the year was due to the excessive amount which fell during July. Great excesses fell during June and September, and the fall during all the summer and autumn months was invariably above the average. The fall was greatly below the average in February, March, April, and December, so that the year was characterised by a dry spring and a very wet summer and autumn, though the excess of the rainfall of the year is about the average fall for a month at this station, yet the number of days on which rain fell is below the average. This usually happens during the periods of excessive rainfall, which shows how much more rapidly the clouds condense during periods of heavy than of light rainfalls; and is another instance of a rule in rainfall that I pointed out last year. The following table shows the results obtained from a rain gauge with a 10in. round receiver placed 3ft. above the ground.

Quarterly Periods.		1875.	Fall in Inches.	Average of 15 years.	Differences.	Quarterly Periods.	
Average of 15 years.	1875.					Average of 15 years.	1875.
Days.	Days.						
52	49	January	3·469	2·857	+0·612	7·336	5·081
		February	0·833	2·103	—1·270		
		March	0·779	2·376	—1·597		
46	44	April	0·763	1·913	—1·150	6·729	7·336
		May	2·676	2·116	+0·560		
		June	3·897	2·700	+1·197		
53	56	July	5·624	3·223	+2·401	10·692	15·180
		August	4·067	3·333	+0·734		
		September	5·489	4·136	+1·353		
58	56	October	5·030	4·310	+0·720	10·514	10·295
		November	4·099	3·325	+0·774		
		December	1·166	2·879	—1·713		
209	205		37·892	35·271	+2·621		

In the next table are given the results obtained from rain gauges of two different kinds, placed in close proximity in the same plane, and 3ft. from the ground, the one has a 10in. round receiver, and the other a 5in. square receiver. Nearly all the months on which there was an excess of rainfall the smaller gauge registered the larger amount; out of the four months when the rainfall was below the average three of them show the greater fall in the greater gauge. Nearly the whole difference between the fall in the two gauges occured in January. A similar circumstance happened in the December of the previous year, that is in the preceding month, and both cases were doubtless due to the same cause, namely the fall of snow. An average fall in both gauges over a period of eight years shows a difference of only $\frac{29}{1000}$ of an inch. Thus as I have said before the two gauges are practically checks upon each other.

1875.	Rainfall in inches in 10in. round receiver 3ft from ground.	Rainfall in inches in 5in. square receiver 3ft. from ground.	Difference.	From 1868 to 1875.		Difference.
				Average of 8 years rainfall in inches in 10in. round receiver 3ft. from ground.	Average of 8 years rainfall in inches in 5in. square receiver 3ft. from ground.	
January	3·469	4·062	—·593	3·082	3·142	—·060
February	0·833	0·824	+·009	1·974	1·940	+·034
March	0·779	0·724	+·055	2·203	2·227	—·024
April	0·763	0·779	—·016	1·853	1·827	+·026
May	2·676	2·690	—·014	2·008	1·978	+·030
June	3·897	3·956	—·059	2·548	2·522	+·026
July.....	5·624	5·710	—·086	3·148	3·143	+·005
August	4·067	4·056	+·011	3·372	3·351	+·021
September.....	5·489	5·497	—·008	4·069	4·030	+·039
October	5·030	4·960	+·070	4·983	4·967	+·016
November	4·099	4·118	—·019	3·272	3·306	—·034
December	1·166	1·131	+·035	3·023	3·073	—·050
	37·892	38·507	—·615	35·535	35·506	+·029

In the next table I give the results obtained from two exactly similar gauges placed at different heights from the ground and free from every interference; each gauge has a 5in. square receiver, and the one is placed 3ft. and the other 34ft. above the ground. The total fall in the one 3ft. from

the ground for last year was 38·507in., and in the one 34ft. from the ground it was 32·921in. The difference between the fall in the two gauges is 5·586in. or about 18 per cent less rain fell in the higher gauge than in the lower one. In the same table I give the average fall in the same gauges for eight years, and by comparing the results it will be found that the average difference between the fall in the two gauges is about 17½ per cent, very nearly the difference I showed last year on a seven years' average.

1875.	Rainfall in inches in 5in. square receiver 3ft. from ground, 1875.	Rainfall in inches in 5in. square receiver 34ft. from ground, 1875.	From 1868 to 1875.	
			Average fall of rain in inches for 8 years in 5in. square receiver 3ft. from ground.	Average fall of rain in inches for 8 years in 5in. square receiver 34ft. from ground.
January	4·062	2·613	3·142	2·217
February	0·824	0·585	1·940	1·461
March	0·724	0·605	2·227	1·748
April	0·779	0·543	1·827	1·545
May.....	2·690	2·345	1·978	1·784
June	3·956	3·326	2·522	2·220
July	5·710	5·312	3·143	2·819
August	4·056	3·791	3·351	2·852
September.....	5·497	4·917	4·030	3·453
October	4·960	4·605	4·967	4·154
November	4·118	3·464	3·306	2·597
December	1·131	0·815	3·073	2·460
	38·507	32·921	35·506	29·310

The following table gives the ratios of the excesses of rainfall 3ft. from the ground over the amount measured at 34ft. from the ground. It is astonishing how these ratios vary their places in each single year, and yet how they maintain their positions in and after a six years' average. There was absolutely no comparison between the ratios of the single years of 1873 and 1874 and the ratios of the six and seven years' averages, which were almost identical. So also of these ratios of last year, there is not the slightest comparison between them and the eight years' average, and practically there is no difference between the six, seven, and eight years' averages. Now, according to the seven and

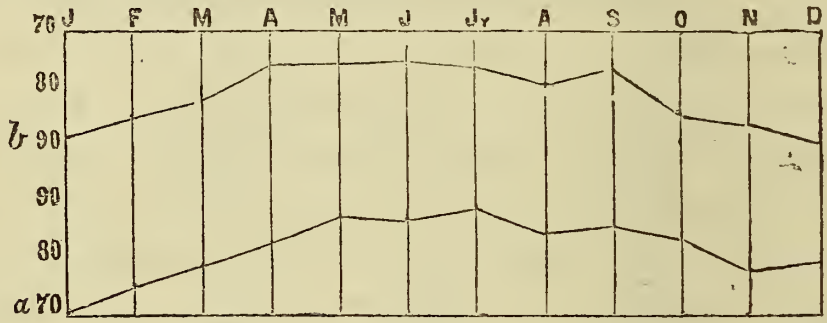
eight years' averages, the greatest difference between the amounts of rain which fell in the lower and higher gauges occurs in January, decreases gradually in difference till May, when it attains a minimum. This minimum maintains itself till August, when there is a slight increase; then after a slight decrease in September, the increase becomes constant to January again. On the theory first enunciated by Mr. Baxendell that the excess of rainfall in the lower gauge is due to the particles of invisible vapour in the air between it and the higher gauge coalescing with the falling rain-drops, the results seem to show that in the spring and early summer months there is relatively less of this vapour in the air below a height of 34ft., and there is relatively more of it in the winter months and particularly in January.

Monthly and annual ratios of the excess of rainfall measured at 3ft. from the ground over the amount measured at 34ft. from the ground; together with the amount of the mean humidity of the atmosphere, full saturation being represented by unity.

	Ratios of such rainfall for 1875.	Ratios of such rainfall for an average of 8 years, from 1868 to 1875.	Mean humidity of the atmosphere for 8 years, from 1868 to 1875.
January	·643	·705	·871
February	·709	·753	·855
March	·835	·784	·836
April	·697	·845	·765
May	·871	·901	·755
June	·840	·879	·747
July	·930	·896	·759
August	·934	·851	·793
September	·894	·856	·777
October	·929	·836	·840
November	·841	·785	·853
December	·720	·800	·872
Annual Ratios	·820	·824	·810

That I might demonstrate as far as possible that this is the true way to account for the difference of rainfall at the two heights above the ground, I took out the representatives I had for the last 8 years of the relative amount of moisture in the atmosphere. These results were obtained from a

wet and dry bulb hygrometer, which I have had in use for 16 years, and reductions based upon Glaisher's humidity tables. In the foregoing table the averages of the relative amount of moisture in the atmosphere are given in the last column. Of course the order of the amounts is inverse to the ratios of rainfall, one being positive and the other negative. The striking resemblance between facts shown by each is at once obvious. I have, however, projected them in the following diagram. The irregular line marked



(a) represents the rainfall ratios, and the one marked (b) the mean relative amount of humidity. Hence I infer that the maximum of dry air on the ground is in May, June, and July, and the minimum in November, December, and January. These periods of maximum and minimum are closely allied to similar periods of ozone results.

In the next table I give the fall of rain for 1875 during the day, from 8 a.m. to 8 p.m., and the fall during the night from 8 p.m. to 8 a.m. The results of these observations for 1874 I pointed out were exceptional, as in every previous year since I instituted them the day-fall had always been greater than the night-fall. The last year gives the original kind of results, and the day-fall exceeds the night, and by about the same amount as the reverse of 1864. The excess of the day-fall over the night of last year was 2·517 inches, or about 13 per cent.

1875.	Rainfall in inches from 8 a.m. to 8 p.m.	Rainfall in inches from 8 p.m. to 8 a.m.	Difference between night and day fall.
January	1·605	2·457	+0·852
February	0·468	0·356	—0·112
March	0·380	0·344	—0·036
April	0·396	0·383	—0·013
May	1·249	1·441	+0·192
June	2·425	1·531	—0·894
July	3·780	1·930	—1·850
August	2·033	2·023	—0·010
September ...	2·410	3·087	+0·677
October.....	2·759	2·201	—0·558
November ...	2·584	1·534	—1·050
December.....	0·423	0·708	+0·285
	20·512	17·995	—2·517

In the next table I present the average day and night fall for a period of eight years. The results of this table continue to show that the day-fall exceeds the night-fall so far as the whole year is considered. The months which have an excess of rainfall in the nights are those which show the greatest amount of atmospheric vapour, namely January, February and December; August and September show an increase, but in these months the amount of vapour in the air begins to increase, but whether the excess in those months is due to that cause is yet doubtful.

Average of eight years, from 1868 to 1875 :—

1875.	Rainfall in inches from 8 a.m. to 8 p.m.	Rainfall in inches from 8 p.m. to 8 a.m.	Difference between night and day fall.
January	1·361	1·781	+0·420
February	0·825	1·114	+0·289
March	1·199	1·027	—0·172
April	1·054	0·772	—0·282
May	1·156	0·821	—0·335
June	1·463	1·058	—0·405
July	1·813	1·330	—0·483
August	1·656	1·695	+0·039
September ...	1·875	2·155	+0·280
October.....	2·585	2·381	—0·204
November ...	1·682	1·624	—0·058
December.....	1·351	1·721	+0·370
	18·020	17·479	—0·541

MICROSCOPICAL AND NATURAL HISTORY SECTION.

March 13th, 1876.

Professor W. Boyd Dawkins, F.R.S., F.G.S., in the chair.

Mr. John Boyd was elected a Member, and Mr. Robert Ellis Cunliffe, and Mr. Walter Edward Barratt, Associates of the Section.

Mr. Charles Bailey exhibited a series of slides illustrating similarities of structure in Dicotyledonous and Monocotyledonous stems.

Mr. Bailey likewise distributed among the members dried plants of Potamogaton lanceolatus sm. from Lligwy, Anglesea, that locality being still the only recorded habitat for this rare Pondweed; and exhibited some Egyptian plants collected by H. A. Hurst, Esq., Treasurer of the Section—the most noteworthy of which was Tamarix articulata—from Alexandria.

Mr. R. D. Darbishire, F.G.S., exhibited a series of specimens of very young Rhombus vulgaris (Cuv.), showing (1), the two eyes on each side of the vertebral plane, (2) the removal of the eye from the underside to the dorsal edge, (3) the appearance of both eyes on the one (upper) side of the fish. These specimens had been found and given by Dr. A. W. Malm, of Gothenburg; who first proved the remarkable physiological change of form. Dr. Malm stated that he had had no difficulty in procuring specimens so young as these by using a surface net at sea before dawn in the hot days of summer. These were taken in the Kattegat on the 25th July, 1875.

Mr. R. D. Darbishire, F.G.S., also communicated some notes made during a visit in the past summer to the Swedish shell-beds of Uddevalla and the neighbouring district, and exhibited a collection of the fossils of remarkable extent and beauty. He referred to the notices of these fossils by Linnæus, 1747 (9 species), and others; by Sir C. Lyell, 1834, in his paper on the proofs of a rising of the land in Sweden (Philos. Trans. 1834) (25 species); by Mr. J. G. Jeffreys, 1863, British Ass. Rep. (85 shells, and 14 other invertebrata), and M. Thudén, 1866 (116 specimens of shells), and to the great collections of Mr. R. Thorburn in the Museum of Uddevalla, and Dr. Malm in that at Gothenburg. The two latest lists must be used with discrimination as they are conchological rather than geological; each enumerating in one consecutive list fossils from older, newer and comparatively recent beds.

He described the great deposits at Kapellebacken S.W. and at Samneröd, Bräcke and Kurod, N.E. of Uddevalla, and noted especially the following facts as proving that, whether the greater part of those vast accumulations of remains had been drifted into the bottom of the ancient fiords or not, some at least of the shells had lived where they are now found. The perfect and unviolated occurrence of the species named, the horizontal position of the small beds of sand and shingle in which some of the shells are found, point to very steady and slow movement. Sir Charles Lyell indicated the present rise of the southern part of Sweden as at the rate of 3 feet per century. As the highest beds at Uddevalla are about 206 (English) feet above the level of the sea, this means that they have been rising for at least 7,000 years. How long it was before they emerged from the water, that the lower parts of the deposit, which at Kapellebacken are apparently more than 70 or 80 feet thick, were laid in the bottom of the sea, there is no record. The most elevated beds of the district appear to be those at

Kapellebacken. In a small quarry, where the material has been worked for agricultural purposes, the following shells were found under conditions which imply that they lived where they now lie. They occur in horizontal patches, shewing on the sections as level, and remarkably limited strata. There is, at a level many feet below the top of the older deposit, a curious patch of much more modern raised beach with Littorina littorea and Cardium edule.

This bed also is horizontal and undisturbed.

Mya truncata: The two valves together, upright in sandy shingle, and filled with the same.

Mytilus Edulis: In beds, the valves of various sizes lying confused and packed. In this species the ligament and hinge are weak and the valves speedily detach themselves. One pair was found in the mouth of a baccinum, which could scarcely have rolled over after its lodger had died without losing his shell.

Modiola Modiolus: In a bed of fine sand shells of this species occurred in a remarkably perfect condition, the valves closed, posterior edge uppermost, the hinge and back at the top; large shells and smaller (all of a more fragile variety than is commonly dredged in British seas.) In digging back into this layer shell after shell appeared; while fresh, "as perfect as if alive," but soon to warp and crack in drying.

[Query: Does this Modiola ever live burrowing free in fine sand?]

Pecten Islandicus: In beds, large and small, the valves together, horizontally, with the flatter valve uppermost. The colour of this shell is often preserved with extraordinary freshness.

Buccinnum undatum: and B. Greenlandicum: Both species occasionally occurred, older and younger shells together, grouped in horizontal strata, though, naturally, not so massed as the less locomotive bivalves, and besides, generally diffused through the whole deposit.

Fusus Antiquus: Also occurred, though not massed, old and young shells free from sea-wear.

Echinus Dröbachiensis: Also occurred in sandy layers, grouped, old and young, as these animals are usually found to live.

Balanus Hameri, a species whose component plates seem very slightly attached to each other, and speedily fall apart after death and disturbance, occurs whole. It was at this locality that M. Brongniart noticed the basal plate shells adhering to the gneiss rocks, between which the shales are heaped. The like were still to be found there.

In the more amply extended deposits at Bräcke, which do not rise above a level of 100 feet above the sea, there are enormous accumulations of the shells of Saxicava rugosa. Wherever there was a fresh section ready, or could be made, it was easy to pick out multitudes of specimens with the two valves together. As the ligament of this shell is very slight, and the hinge nothing, these pairs of valves cannot have suffered either sea wash or any geokinetic change of position, or even pressure.

The great size and the freedom of growth of the Uddevalla Saxicava has been long noticed, indicating its life outside of such burrows as gave the more modern form its name. One may suppose that the shells, growing at liberty amongst piles of shells of their ancestors, may well have developed, as we see. Both varieties (rugosa and arctica) occur, the latter somewhat more rarely.

At the same place there were found amongst the Saxicava valves, which form, as it were, the matrix of the deposit, many specimens of *Astarte borealis,* old and young, with both valves in juxtaposition, placed vertically with the posterior end uppermost, in the position of life. *Astarte elliptica* occurred also in the same condition, though more rarely.

It was at Bräcke that Sir Charles Lyell found the balanus hameri still attached to the rocks.

Saxicava arctica, Mya truncata, and Mytilus edulis appear in forms peculiarly distorted, in a way which it is usual to attribute to exposure, during intervals, to greater or less infusion of fresher or colder water. This may be supposed to be due to some direction of the currents of the old land streams, probably coming down from glaciers, over shellbeds, not far from shore, and at no great depth. The variation of Mya truncata from some such cause has given rise to the form known as M. Uddevallensis.

Dr. Thomas Alcock has kindly examined three parcels of sand, and reports finding the following species:

	Kapellebacken—high level.		Bräche—lower. From sand among shells.
	From sand in Modiola.	From sand in Echinus.	
Polystomella umbilicatula..	*		*
Miliolina seminulum	*	*	*
„ trigonula.....			*
Rotalina turgida (?)	*	*	*
Truncatulina lobatula		*	*
Another form			*
Mollusca, fry of		*	
Ostracoda	3	2	3

The specimens are all of strong kinds, and appear much worn. They were not common in any parcel.

Mr. John Plant made the following remarks, being addenda and corrigenda to the list of shells already published, found in Cymmeran Bay, Anglesea.

List of Shells found in Cymmeran Bay, Anglesea. Corrections and Additions, by John Plant, F.G.S.

Since the printing of my last list of the Fauna of Cymmeran Bay, the collection of shells obtained from there has been more than once revised, and I have seen reason to believe that in several instances my determination of the species has been faulty, from my having had only

young or greatly worn shells to deal with. Several species have been added to the list of this collection. It is therefore necessary to print a few *corrigenda* and *addenda.*

25. Lucina leucoma, was so named from a few worn and small valves, since which living shells have been taken and it proves to be L. borealis, smaller than normal specimens.

31. Cardium rusticum; this must be given up as belonging to this locality. All my specimens belong to C. echinatum.

96. Venus casina, are shells much worn of V. verrucosa.

97. Circe minima; the one small valve so named proves to be a very young Cyprina Islandica.

99. Cardium fasciatum; the two small specimens so named are young of C. cchinatum.

109. Pecten niveus; the valve so named is a white variety of P. pusio, a common shell in the bay. White varieties of P. varius approaching nearly to the niveus are also found.

39. Acmæa testudinalis; the shells so named are the young of a variety of P. vulgata.

121. Assiminea Grayana are only worn and small forms of Lacuna Vincta and L. puteola.

Fusus Islandicus should be called F. gracilis, the former name has long been applied to this English shell, but erroneously.

The following are additional species which have been satisfactorily determined since the last list was printed.

Venus ovata, several specimens from both Cymmeran and Holyhead.

Artemis lincta, a tew valves.

Cardium echinatum, previously named C. rusticum.

Cardium pygmæum, not very common.

Astarte sulcata, one small specimen.

Lucina borealis, previously named L. leucoma.

Modiola modiolus, not common.

Sphænia Binghami, a good number of smallish specimens.

Trochus Lyonsii, a well marked variety of T. zizyphinus.

Dentalium tarentinum, from Holyhead.

Patella athletica, rather common.

Natica nitida, far from common.

Odostomia acuta (Jeff.), two specimens of a dull white variety, distinctly umbilicated—vide Brit. Mol. v. 3, p. 270.

Sepia bisserialis, Towyn Capel, Defarh bays. Mrs. Plant found four of these beautiful and rare shells after very stormy weather, in August, 1873.

Ordinary Meeting, April 4th, 1876.

Edward Schunck, Ph.D., F.R.S., &c., President, in the Chair.

Professor W. Boyd Dawkins, F.R.S., called the attention of the Society to the depreciation of silver which is now under the notice of a select committee of the House of Commons. It has been attributed to a panic, to the demonetisation of silver in Germany, or to the increased production of silver. In all probability all these causes have been in operation together. With regard to the last he had had the opportunity of examining a part of the silver mining district in Nevada last autumn, and he was very much impressed by the enormous mineral wealth of that region, which is as yet scarcely touched. In spite of the depression of trade, which was marked by the number of miners out of work, new localities are being discovered which will afford an almost inexhaustible supply of silver. To take an example. In June last a new lode was discovered in the range of metamorphic schists and slates about 12 miles from Battle Mountain, a station on the Central Pacific Railway, 519 miles from San Francisco. When he visited it in October it was nearly in working order, and at the present time is in full production. The lode runs N. and S. and outcropped on the surface of the ground, forming a vertical mass looking almost like a broken down wall in some places, and measuring 32 feet wide, the richer portions being of course irregular in thickness.

These metalliferous ranges extend southwards through Arizona and New Mexico into the great Mexican mining districts, and northwards to an unknown limit. The principal obstacles to their wealth being realised are, 1. The hostility of the Indians, 2. The want of wood, 3. The difficulties of carriage. These however are swiftly being removed. The Indians are rapidly perishing, and the railways are bringing places hitherto inaccessible within reach of the seaboard and the Eastern States. And although the lonely plains covered with sage-brush which sweep round the metalliferous ranges almost like a sea, and at a height of from 4000 to 5000 feet, are without a tree, the Sierra Nevada on the one hand, and the Rocky Mountains on the other, offer an endless supply of timber. It seems therefore that the production of silver in this district is likely to be largely increased. Unless the demand keep pace with the supply, the price must necessarily fall. Fourteen tons of silver coined at the San Francisco mint were sent to the Eastern States on 21st of March last, and the export from San Francisco to China, which was under one million sterling in 1874 according to Sir Hector Hay, in 1875 reached one and a half millions, which gives an increase of 50 per cent, and this in spite of the extraordinary depression of trade.

"On some Isomerides of Alizarine," by EDWARD SCHUNCK, Ph.D., F.R.S., and HERMANN ROEMER, Ph.D.

Considering the importance of everything connected with the history of alizarine, we have been induced to undertake the study of such of the isomerides of that body as we have been able to obtain. These isomerides are interesting from a theoretical point of view, as presenting a problem with regard to internal constitution which has not yet been solved, and technically some of them are interesting as they occur along with artificial alizarine and not being available for tinctorial purposes are the source

of loss to the manufacturer. The isomerides of alizarine hitherto observed are the following :—

1. *Purpuroxanthine,* a body first obtained by Schützenberger from commercial purpurine, and afterwards prepared artificially by the action of reducing agents on purpurine. It crystallises in yellow needles, soluble in alkalies with a blood-red colour.

2. *Isoalizarine,* a substance derived from madder and described by Rochleder, having properties very similar to those of purpuroxanthine, and perhaps identical with it.

3. *Frangulic Acid,* a substance also very similar to purpuroxanthine, obtained by Faust by the decomposition of franguline, a constituent of the bark of Rhamnus frangula.

4. *Anthraflavic Acid* or *Anthraflavine,* a body accompanying artificial alizarine, first described by one of the authors in a paper read before this Society,* and subsequently examined by Mr. Perkin. Its isomerism with alizarine was established by Mr. Perkin, who was the first to obtain it in a state of perfect purity. It is easily distinguished by the colour of its alkaline solution, which is yellow.

5. *Anthraflavon,* a product obtained by the action of diluted sulphuric acid on oxybenzoic acid. We have not yet had an opportunity of preparing and examining this body, but on reading the description of it given by its discoverers, Barth and Sennhofer, it is evident that it bears a strong resemblance to the preceding.

6. *Quinazarine,* obtained by Baeyer, by the action of phthalic acid on hydroquinone. Of all the isomerides it most resembles alizarine itself. Its alkaline solutions have the same violet colour as those of alizarine, and it dyes mordants, while the other isomerides have no tinctorial properties.

7. *Chrysazine,* a body formed by the action of nitrous acid on hydrochrysammide, and carefully examined by its

* Memoirs, 3rd Series, Vol. V., p. 227.

discoverer, Liebermann. By the action on it of strong nitric acid it yields chrysammic acid, the nitro-acid first obtained from aloes by one of the authors many years ago.

To these we have now to add—

8. *Isoanthraflavine*, a substance accompanying artificial alizarine, generally found along with anthraflavine in the commercial product, and which we shall describe presently.

Chrysophanic Acid, the crystalline colouring matter of rhubarb, which at one time occupied a place in the list has been erased, since it has been shown by Liebermann that it is in reality a homologue of alizarine, having the formula $C_{15}H_{10}O_4$, and is derived not from anthracene, but from a methylanthracene.

We propose in this paper to give an account of some experiments on two of these isomerides, viz., anthraflavic acid and the one generally accompanying it, which we have lately observed for the first time.

Anthraflavic Acid or Anthraflavine.

We have little to add to the description of this substance given in the paper above referred to. Its melting point is above 330°C. It is less soluble in glacial acetic acid than in alcohol. The analysis of a carefully purified specimen of the substance gave numbers agreeing exactly with the formula $C_{14}H_8O_4$, and confirming the results obtained by Perkin. The barium salt, which has been previously described, loses when dried over sulphuric acid a considerable quantity of water, becoming at the same time much lighter in colour. On being now heated at a temperature of 150°—180°C. it loses two molecules of water, and the dried salt has a composition corresponding with the formula $C_{14}H_6BaO_4$. Our results do not quite agree with those of Perkin, who found the formula of the salt dried at 180° to be $2C_{14}H_6BaO_4$, H_2O.

Tetrabromanthraflavine, $C_{14}H_4Br_4O_4$, is prepared by adding bromine in excess to an alcoholic solution of the

substance. It crystallises in yellow needles, which are almost insoluble in the usual menstrua, such as alcohol, benzol, and glacial acetic acid.

Nitroanthraflavic Acid, a body already referred to in the paper of 1871, is prepared by dissolving anthraflavine in fuming nitric acid and after allowing to stand some time, adding water, which precipitates the nitro-acid as a light yellow crystalline powder. It is obtained on spontaneous evaporation of its alcoholic solution in large well-defined rhombic crystals of a deep yellow colour, the composition of which is expressed by the formula $C_{14}H_4(NO_2)_4O_4$. Most of the salts, such as the potassium, sodium, magnesium, barium, silver, and mercury salts, are soluble in boiling water, and crystallise in lustrous needles, varying in colour from light-yellow to brownish-red. By reduction with tin and hydrochloric acid the nitro-acid yields a dark-blue powder, which is almost insoluble in alcohol, glacial acetic acid, &c., but dissolves in caustic alkalies with a fine violet colour like that of alkaline solutions of alizarine.

Diacetylanthraflavine has already been described by Perkin.* We found its melting point to be at 227°C.

Diethylanthraflavine, $C_{14}H_6(C H_5)_2O_4$ was prepared by heating a mixture of anthraflavine, caustic soda, iodide of ethyl, and a little alcohol in sealed tubes to 120°, and crystallising the product from boiling alcohol. It crystallises in light yellow needles, which are soluble in benzol and glacial acetic acid, but insoluble in water. It fuses at 232°. The fused substance on cooling is converted into a mass of prismatic crystals. The spectrum of the solution in concentrated sulphuric acid, which is red, shows a well-defined absorption band between the green and blue.

Dimethylanthraflavine, the preparation of which is similar to that of the preceding, has almost the same properties as the ethyl compound. It fuses at 247°–248°.

* Journal Chem. Soc. XXVI., p. 20.

Isoanthraflavine.

This isomeride of alizarine was prepared from a by-product of the manufacture of alizarine supplied to us some time ago by Mr. Perkin, and which, according to the latter, had been obtained by treating the crude alizarine with lime-water, filtering and precipitating the red extract with acid. The product was treated with dilute caustic soda lye, in order to separate some anthraquinone. The filtrate gave with hydrochloric acid a yellow gelatinous precipitate, which was filtered off and treated with cold baryta water, until nothing more dissolved. The residue left undissolved after this treatment consisted of barium anthraflavate, and was employed for the preparation of anthraflavine. The blood-red solution was mixed with hydrochloric acid, which gave a yellow precipitate consisting of isoanthraflavine. This was purified by repeated crystallisation from boiling alcohol, and was obtained in long yellow crystalline needles. Sometimes it yielded golden yellow lustrous scales, but these on recrystallisation always gave needles. These needles, after drying over sulphuric acid, still contain one molecule of water of crystallisation, which is driven off by heating to 120°. The dried substance has a composition agreeing with the formula $C_{14}H_8O_4$, five analyses giving as a mean C69·79, H3·65, the calculated amounts being C70·00, H3·33. The properties of isoanthraflavine resemble those of anthraflavine. It melts at a temperature above 330°. When slowly heated between watch-glasses it yields a sublimate consisting of lustrous bright yellow needles and plates. It is a little more soluble in boiling water than anthraflavine. It dissolves easily in boiling alcohol and in hot concentrated sulphuric acid, but is almost insoluble in benzol and chloroform. It imparts no colour whatever to mordants and differs in this respect very widely from alizarine. It may be easily distinguished from anthraflavine by the colour of its alkaline solutions, which is distinctly red, while the

colour of anthraflavine solutions is deep yellow, or when concentrated reddish-yellow. In concentrated sulphuric acid isoanthraflavine dissolves with a cherry-red, anthraflavine with a yellow colour. The two substances may also be readily distinguished by their behaviour towards lime and baryta water, in which isoanthraflavine dissolves easily in the cold, yielding red solutions. Anthraflavine, on the other hand, is almost insoluble in cold baryta water, and only dissolves on boiling, while in lime water it is almost insoluble at all temperatures. Isoanthraflavine in most of its properties approaches purpuroxanthine even more closely than it does to anthroflavine; but having prepared a specimen of purpuroxanthine according to Schützenberger's process, we are enabled to assert positively that the two bodies are not identical. One of the characteristic properties of purpuroxanthine is that it yields phthalic by oxidation with nitric acid, whereas isoanthraflavine gives with nitric acid a nitro-substitution product.

The barium compound of isoanthraflavine can be made to crystallise (though not without some difficulty) in dark red needles resembling barium anthraflavate. It contains water of crystallisation, which it loses on being heated to 150°. The composition of the dry salt corresponds with the formula $C_{14}H_6BaO_4$.

Tetrabromisoanthraflavine, $C_{14}H_4Br_4O_4$, is prepared in the same way as tetrabromanthraflavine. It crystallises in yellow needles, soluble in boiling alcohol and in glacial acetic acid.

Diacetylisoanthraflavine, $C_{14}H_6(C_2H_3O)_2O_4$ was obtained by the action of acetic anhydride on isoanthraflavine at 160 to 180°. It crystallises in light yellow microscopic needles, which are soluble in alcohol and more easily soluble in glacial acetic acid. At 175° it commences to soften, and at about 195° it fuses completely. It is decomposed by alcoholic potash solution.

Diethylisoanthraflavine, $C_{14}H_6(C_2H_5)_2O_4$, was prepared in the same way as diethylanthraflavine, which it closely resembles. It crystallises from alcohol in long light yellow shining needles, soluble in alcohol and ether, more soluble in glacial acetic acid and benzol. It fuses at 193—194°. It dissolves in concentrated sulphuric acid, forming a purple solution, the spectrum of which shows two ill-defined absorption bands, one in the yellow, the other in the green.

Isoanthraflavine gives with fuming nitric acid a nitro-substitution product similar in its appearance and general properties to nitro-anthraflavic acid, but we have been unable from want of material to examine it minutely.

We will conclude with a few remarks on the action of caustic alkalies on anthraflavine and isoanthraflavine. On a former occasion it was stated by one of us that anthraflavine yields by the action of fusing hydrate of potash alizarine, and it was this supposed convertibility into alizarine which led Liebermann and others to the conclusion that anthraflavine was identical with monoxyanthraquinone. We are now in a position to assert with confidence that the product of the action of alkalies is not alizarine. On repeating the experiment on a larger scale by fusing the substance with caustic potash in a silver basin we obtained a substance which after being freed from impurities crystallised from alcohol in orange-coloured needles strongly resembling but certainly not identical with alizarine. On heating it yields a sublimate in needles very similar to sublimed alizarine. The solution in alkalies is however devoid of the violet tint characteristic of alizarine, and on dilution appears distinctly red. The spectrum of the solution shows two absorption bands similar to those of alizarine solution, but these bands, according to the determination kindly undertaken for us by Dr. Schuster, lie further away from the red end than the bands of alizarine. It appears probable that this body may turn out to be an isomeride of purpurine, resem-

bling Mr. Perkin's anthrapurpurine. Isoanthraflavine when treated in the same way yields a body which has most of the properties of anthrapurpurine, though it seems to crystallise more readily and in longer needles than the latter substance does, according to Mr. Perkin's account. We are at present engaged in the investigation of these products.

Professor Boyd Dawkins, F.R.S., made the following remarks :

It is not my intention to add more than a few necessary words to the literature, serious and comic, which has Windy Knoll for its centre. At the last meeting I was unable to give a decided 'yes' or 'no' to Mr. Plant's evidence that the 'bone of contention' was not that of bison, because it is a fragment of a variable and unimportant bone which I had not seen for nearly two years. I have re-examined the evidence, and consulted Mr. Davies, of the British Museum, and I find that I was mistaken in referring it to bison. The mistake is however a side issue and not of any scientific importance, because the remains of that animal from that place are considerably over one thousand in number, while those of the bear are over sixty,

With regard to the real point at issue, as to whether it adds the cave-bear to the fauna of Derbyshire, as urged by Mr. Plant, I have only to add to the opinion expressed in Proceed. of Lit. and Phil. Soc., Manchester, 1874, p. 6, the views of Professor Busk and Mr. Davies. The former writes—"I should be very loth to give any opinion whatever as to the specific characters of a fossil bear from that part of the skeleton alone." The latter, after regretting that Mr. Plant had omitted to mention the discovery of the associated ursine jaws and teeth when the bone was submitted to him, says (25th March, 1876), "I have not sufficiently studied the bones of the bears, with the exception of the jaws and teeth, as to enable me to determine with certainty the species to which they belong. Had I known

all the facts, I should not only have hesitated but refrained from assigning the bone to any particular species of bear." The evidence of the jaws and teeth proves that the bear of Windy Knoll is not the cave, but the great fossil grizzly bear (*U. ferox fossilis*=*U. priscus*), as may be seen by a reference to the Quart. Geol. Journ., Lond. 1875, pp. 251-2. It is unnecessary to go into further details.

"The Eucalyptus near Rome," by Dr. R. ANGUS SMITH, F.R.S., V.P.

A few years ago I wrote to a friend in Italy, suggesting that, as he had leisure, he might try the value of the Eucalyptus in that country for the removal of those conditions which engender malaria. His reply was somewhat to the effect that every one was aware of the value of the tree, and everywhere trials were being made, so that there was no use in his doing what everybody was doing. This was very cheerful, showing how rapidly the Italians had risen up to a full appreciation of new ideas. This winter I went to Rome with a desire to learn on the spot something of the conditions of the ground complained of, and receive some knowledge from the learned men of the place, as well as from any books which may not be well known here. I certainly did not obtain any confirmation of the opinion that every one was attending to the subject. I saw men in scientific and social positions, in which one might expect to find the fullest knowledge of the subject, and I came to the conclusion that it had excited very little interest in Rome or the neighbouring country.

One small experiment, however, was spoken of, and several knew of it, although I met few who had seen it. It was made at the Church of St. Paolo alle Tre Fontane (usually called *Tre Fontane*), three or four miles from Rome, and as this is the only place I have seen from which to derive a lesson, I must be excused taking such a small

example. The church has two other churches near it, and a small residence for monks of the order of La Trappe. The station had been deserted for 40 years, and the ancient building—the largest and lowest in situation—had been filled up with mud to the depth of three feet. The Campagna here is much exposed to malaria, and hence the desertion. It is by no means a dead level, neither is the upper part of the Campagna or agro Romano by any means so. The soil is very deep, and it is cut into vales of a depth which I will not venture to characterize generally, but enough to say, they were at this place 30 to 40 feet. The streams, like the Tiber itself, had brought down their mud, and the place had become to a large extent a desolation. In 1869 it was re-inhabited; and before entering on the dwellings, a number of prisoners were set to clean out the place, remove the accumulated mud, and make drains. Round the desolate spot there is now a garden, and although it is not yet in fine order, it is, at least in sunshine, a great improvement on the neglected land around. I venture to give no exact history, but tell only such few things as were told me at the spot. During the first season several of the monks died—I think five was the number given—and of fever such as marshes produce. A few specimens of Eucalyptus Globulus were planted, and, as they grew well, a small garden is now thinly covered over with various species. As one enters there is a peculiar odour perceptible, it is fragrant, pleasant, and resinous; some compare it to that from turpentine, some to the black currant, but every one attempts to give the name of some other odour as evidently mixed with this more prominent one. The most of the plants are two or three years old and about ten feet high; but there is a diversity, and the oldest has been planted only five years. This largest was judged by myself and others to be about thirty-five feet high: at the height of fourteen inches from the ground it was eight inches in diameter.

Not one of the monks had died after the first year, but then the place had not been inhabited during the night until last summer. Still, it will be seen that the experiment is a very small one and a very imperfect one. It is, however, important in this respect, that during the last summer and autumn—the dangerous seasons—no one had died, whilst during the first there were several deaths. But it must be remembered that the place had been cleaned out and drained, and placed, as the buildings were, in the lower part of a valley, draining must have been much required, and the fact of mud being in the church itself, showed how readily the whole was flooded. Although there are now some trees growing, they are only at one side and they are small. It is true they give out a very distinct odour very striking when one goes near, and it may be said that the cause must pervade all the surroundings even if it be not perceptible. This will certainly take place in very still weather, and the low situation protects it greatly from winds. Still, with every desire to give to the emanations of the Eucalyptus every virtue demanded, it is not easy to look on this as a good instance of its success.

One of the monks by name Orsise, had prepared a tincture from the leaves, and a glass of this was given to every one daily when fever showed itself. This seems to have been the really efficient agent that in conjunction with the drainage protected the brethren last summer.

It is not my intention to speak of this substance with details to any extent. It is however known that in the leaves and the bark and even wood of the blue gum tree is an oil with a very strong odour. There may rather be said to be several oils, but one which has been called eucalyptol boils between 170° and 178° C. This is the oil which is said to resemble cajeput oil, and is said to have an effect similar to that of quinine. But the substance which has the medical effect is probably a much more volatile oil continually

rising from the plant, and J. Bosisto adds a volatile acid.*

This experiment mentioned shows that men may live in health in one of the worst parts of the Campagna with proper precautions, and how different would things be if this plan were general; instead of a neglected country with scarcely a house, it might be a pleasant habitation, as it once was, for many thousands. Still we should not expect this to occur if the inhabitants were obliged to take tincture of eucalyptus leaves very frequently. Indeed the use of the tincture is itself an objection to the experiment. The difficulty into which Sir Samuel and Lady Baker got when detained in Africa was aggravated by fever of a marsh kind, but seems to have been entirely removed when they used the spirit from the sweet potato. The fever was not a severe one, but the fact injures to some extent the experiment at Tre Fontane.

If however we look to other countries we are informed that the tree itself with its exhalation is quite sufficient to render a district healthy, and it is perfectly certain that if the oil is efficacious, and the evidence gives faith, those who live near must be continually taking in doses which must soon equal in amount that usually given as a cure. They must in fact be living in a constant vapour of this healing oil. In order to produce this condition the houses must be surrounded with the trees, and every wind will then blow its measure of health. At Tre Fontane this is not attempted, and although more ground has been promised the monks, it is not promised to extend on every side so that they may manage to be surrounded.

In speaking of the subject it of course occurs to ask: Is it really certain that this tree will destroy the malaria, and if not certain, will the expense not be a most alarming one? Can any one venture then on giving advice on the subject? This last is the very point which I look on as so clear.

* See "*Is the Eucalyptus a fever-destroying tree?*" by I. Bosisto. Roy. Soc. of Victoria, 1874.

I do not pretend to give from my own experience any information on the curative powers of the oil, but I have read enough on the subject to satisfy me that the character given to the plant is well founded. A brochure by Dr. Carlotti*, of Corsica, goes over the whole subject very fully, and journals in abundance have treated the subject. But strong as I believe the arguments are, I would conclude that even if they were weak the tree ought to be encouraged and grown largely, because if the benefit of the curative agency were less there is another advantage arising, and that is from the nature of the wood. I went to Tre Fontane with a friend who planted about a million and a half trees in this country annually, and had studied the growth carefully, and he said that the best growing tree would require about thirty years to grow the wood made in five years by the eucalyptus. The question I then asked was this: Does this rapid growth arise from the difference of climate in Scotland and Italy? But the surprise of the Italians at the rapid growth was equally great, although I am not able to tell the difference of increase of the same kind of tree in the two countries. See on this also the book quoted.

M. Lambert, quoted by M. Carlotti, gives the growth in Algeria thus:—

Circumference in centimetres after			1	year	... 10
„	„	„	2	years	... 13
„	„	„	3	„	... 30
„	„	„	4	„	... 40
„	„	„	5	„	... 55
„	„	„	6	„	... 75
„	„	„	7	„	... 90
„	„	„	8	„	...1·20
„	„	„	9	„	...1·50

M. Carlotti has seen the growth from 11 months to be equal to 17 cent. in circumference.

* Assainissement des Régions chaudes insalubres par Regulus Carlotti. (Ajaccio, 1876).

Wood about Rome is scarce; people are cold in winter and would gladly use a fire, and they put cloaks on even in their houses I am told. True, their winter is short. It is a very expensive thing to have a fire in a hotel, and one can easily burn five francs' worth of wood in a day, or at the rate of seventy pounds' worth a year for a fire in one small room. People have not fires enough for the wants of a full civilisation. Even large hotels allow their fires to go out in the evening, and cooking at unusual times cannot be accomplished. The wood of a gum tree five years old is larger than necessary for firewood, and would at any rate be of a most convenient size for splitting up. It is too large near the ground to be used entire, and much larger than any of the wood which I got in Rome or Florence.

Let us imagine this as a source of fuel, a portion of the Campagna, Maremma, Pontine marshes, &c., growing such a crop of combustible matter every five years. Where else will be found a coal field equal in value? Let the power obtainable from this be calculated.

Professor Boyd Dawkins tells me that Sir Charles Nicholson, late Governor of Queensland, had proposed planting the gum trees in Italy twenty years ago, and had sent seed enough to have covered the Maremma with trees, but we see what has been done.

Speaking with a Roman senator on the subject, he said it would take thirty years to grow the trees, and man was a shadow and could not look so far. I know that man is mortal, but have often heard that Rome is eternal, and it is for the future we must act. This senator had the same idea we have here of thirty years for a pretty strong stem, but now it is reduced to five with apparent certainty. These five years themselves may be reduced, because at two years the trees give out rich odour, and perhaps when still younger, and thus they begin to work almost at once, preparing wholesome habitations. The evidence seems to be

that in the second year the homesteads would with care be habitable, and in five years there would be a rich crop of wood off the plantation, whilst the ground cultivated for other purposes would be richer of course, because it would be receiving that attention which for a long time it never has had. The trial in this point of view ceases to be a speculation; it is a fine opening for producing wealth and comfort. Even if the malaria were not removed the gain from the wood would be great.

It is said that the tree will not grow if the temperature falls below 4° C, or about 25°—26° Fahr. One specimen had lost the top leaves by frost; but the great fact remains that they lasted the five years required. There are many varieties of the tree, and some grow in Australia at the height of 4,000 feet, but I cannot learn if these produce as much wood or oil as the globulus; if they do, they promise to be valuable in this country. The eucalyptus viminalis was said to be the best for drying up swamps, and it had the appearance of a willow; but it was by no means so full of oil to all appearance or so fragrant as the eucalyptus globulus. The eucalyptus coccifera never suffered at all from the frost at Tre Fontane, but it had not been long tried; still the attempt was made in its tenderest years.

M. Bosisto says that the Eucalyptus Amygdalina grows 350 feet on high undulating forest land, but not above 100 miles from the coast. This may be the best species for Italy. M. Carlotti seems to recommend the Globulus; M. Bosisto's remarks seem to favour the amygdalina.

The conclusion arrived at was that the frost of the Campagna would not hurt to any great extent any species of the tree tried there, and the principal specimen especially. Nearer the Sabine hills it was said not to grow so well, but there is abundant low land where it is required.

The value claimed for the eucalyptus is intelligible if we consider it as continually giving out a medical agent. So

far as we know this medical agent, when constantly inhaled, has no unfavourable effect, a result not very usual; but it is difficult to compare it with others, because in no cases can we take medicine in doses so minute, constant, and equable. There is room here for a very interesting inquiry.

One virtue claimed for the tree is not so clear—namely, its drying up of swamps. This has been accounted for by its wonderful rapidity of growth; but I do not hear that it requires wet ground to grow upon, and am told that it grows in Australia in very dry places.

M. Bosisto mentions cool refreshing draughts of water obtained from the trunk of the *dwarf trees* in the region of the river Murray. Still one would be glad to hear more on this point. These dwarfs are only 25 feet high.

A paper read before the Royal Society of Victoria by I. Bosisto shews a great variation in the amount of oil. He says the *Euc. Odorata* yields 7 fluid ounces from 2000 lbs. of leaves attached to small branchlets.

Viminalis.....	the same.
Rostrata	15 ounces.
Obliqua	80.
Globulus	120.
Sideroxylon.....	160.
Oleosa	200.
Amygdalina.....	500.

I suppose these numbers to represent the total amount of oils and resins.

In a report on the strength of wood, published by the Science and Art Department, Kensington, the Eucalyptus stands high, but as there are several species from several situations the numbers vary considerably.

In a list where the highest breaking weight is 11,158 lbs. in the case of white or pale iron bark, the blue gum of N.S. Wales is 7,364 to 6,860, of Queensland 5,663, 4,074, 3,416, and as a means of comparison, may be given Russian

Larch 2,142, White Cedar, Queensland, 2,105; the blue gum, therefore, takes a high position.

That drying is an important element in the removal of the causes of malaria cannot be doubted in the most of cases, but it is by no means apparent in all. It cannot be doubted that Garibaldi's plan of having another passage for the Tiber south of Rome would be of great advantage, but especially to the city itself, which is so frequently inundated, and which must, therefore, be on a foundation exceptionally wet. The mud brought down is proverbially great; but so far as I could judge it was not so fine as that of the Nile, which, however, I have seen only in bottles. The Egyptian mud causes no fevers; perhaps because it is more rapidly dried up. The mud of the Tiber is deposited on a very deep soil, but the same occurs on the Nile. The depth of mud, however, may have an important bearing in a less burning sun.

The mud of the Tiber seems always to have been remarkable, and one wonders why it should be able to go on so long unchanged, but on going up the river the difficulty ceases; there we find mud hills, many of them conical, all with steep sides and nearly all without any vegetation except below in some cases. There is in fact from water an enormous deposit raised to a great depth, and enough to keep the Tiber as muddy as ever for ages. It seemed to me that all this fine earth would be very valuable in much of our country, where we are glad of a few inches over chalk, or of a little soil scattered among large stones. Here it lies in great excess, cut into millions of little valleys, a fine study for those who wish to examine the action of streams, but a land wasted and almost useless. If these were made to bring out crops there is room enough for a great population to live, and if crops were closely grown, the mud would proportionately cease to flow. There is a good deal of friendly interchange of favours to be made between the lower and upper Tiber. That this is possible seems to be proved from

some of these hills being covered, although there are few in this condition. It may be difficult to coat the steep sides with any vegetation, but when the top is covered this difficulty diminishes. Still this is work for many men and for a long time.

A peculiar feature of the unwholesome land struck me. It began exactly at the foot of the hills. There was no gradual slope, but you came down from the hill and were at once on the plain stretching out for miles. This, of course, favours violent floods, and may be coexistent with very bad drainage of the plain. Still, as it has been remarked, the Campagna around Rome is not a plain surface, neither are the lower parts the least healthy.

I hope to think more fully of this if I describe the various opinions on the cause of malaria; at present it comes only incidentally. The great engineering works which only governments can undertake promise to be of value, but the planting to which I specially allude seems to point it out as the work of private men. This view of the subject, if correct, must be most comforting to Italy, because it prevents that delay which is needful before great numbers can be brought to act in concert. If enough can be done privately to enable the agricultural labourers to inhabit the plains without fear, the larger schemes will come in time. The Tiber is dammed up by bridges, and one, namely Pons Sublicius, lies now at the bottom, and the water flows over with difficulty. No wonder the bed rises, and no wonder the Tiber bursts all bounds at times. It did so even in the time of Horace, who tells us in his second ode his fear of another flood as in the time of Pyrrha, when the fish rose into the trees or paid a visit to the mountains.

This shows that even by reducing the bed of the Tiber to the level it had in the time of Augustus, floods would not cease, and deepening is not at all likely to be a sufficient measure. It is a pity that the double bed should be so

expensive. That is, however, not for private action; but the use of the eucalyptus is for all who live on the plains out of town.

This fear is greater now, and the ground less wholesome; but of that and the inquiries of Dr. Balestra and others I hope to speak after some time. At present I shall content myself with a few recommendations.

The conclusion to which I come is that enough is known to prove that great benefit may be expected from the cultivation of the eucalyptus globulus and perhaps more from other species. The best plan to begin would probably be by surrounding with trees any house to be inhabited in a district subject to malaria. That the benefit seems to arise in the second year, as soon as the plants give out a great deal of odour. That the experiment near Rome is very small and somewhat mixed, but is nevertheless enough to give great hope to those who have an opportunity to try the same in the Campagna and elsewhere. That the experiments made in other countries seem to indicate a certainty of benefit. That, the value of wood being great near Rome, the eucalyptus promises a substance much wanted and there is therefore a double reason for growing it. That the growth is unusually rapid, so much so that even in five years the wood is much larger than that usually employed for burning in Rome. The expense of the crop is therefore small, and Rome is thus promised both a supply of health, of warmth, and of power by the outlay of little money and with little labour. Apparently Rome need never envy us our coals, for her coal thus got will last for ever.

I have made no new discovery in relation to this subject, but have only put together a few of the more striking points,

that my Roman friends may be induced to stimulate action in those who are more directly concerned, and not leave neglected such a promising source of comfort and of national wealth. For not only is this great source of power to be obtained in the rapidly growing wood, but the removal of malaria is the introduction of better cultivation and additional wealth from other crops.

Professor Boyd Dawkins. F.R.S., remarked that in Australia and Tasmania the eucalyptus grows in almost every sort of situation and from the sea level to a height of several thousand feet above the sea. It is to be seen growing equally well on arid rocky soil based on thick sandstones, analagous to our millstone grit, and on swampy ground. In the Blue Mountains a ridge of carboniferous rock rising in New South Wales to a height of 3,000 feet above the sea, it is subjected to considerable extremes of climate. At Mount Victoria, for example, on the 7th of August, 1875, there was a heavy fall of snow followed by a frost; and this, I was told, was by no means unusual in the winter. It seems, therefore, that some varieties of eucalypti can stand a moderate amount of cold, and I see no reason why, if it be thought desirable to grow so ugly a tree, it should not be naturalised in this country. On this point, however, I have a letter from Sir Charles Nicholson, Bart., which is an important contribution to the history of the introduction of the plant into Europe.

[copy.]

"Some years since I wrote to the Government botanist at Melbourne, suggesting to him the possibility of acclimatising

some of the harder varieties of the eucalyptus in the British Islands; and at the same time asking him to procure me the seed of any plants belonging to that family whose habitat was alpine, or that belonged to the most southern and colder parts of Tasmania. In compliance with this request he sent me a collection of seeds, which, however, I suspect were nearly all derived from the neighbourhood of Melbourne, Gipps Land. I had them sown in pots, and kept the young plants in a greenhouse for a couple of years. They grew with such rapidity that I no longer had any space for them, and after giving away a number of plants, I turned about half a dozen out into the open air. Three or four of the specimens (they were all of the s. eucalyptus globulus or quadrangular) seemed scarcely to feel the change, and in the course of some four years attained a height of about ten or twelve feet. The other specimens put out in the open air were cut down each winter, growing again from the root with the return of each succeeding spring.

"Such has been the result of my experience up to within the last fortnight. Two days ago, however, on going to my farm in Essex, I was disappointed to find that my trees, which had so successfully resisted the frosts of four winters, had in consequence of the late severe weather been seriously affected, the greater part of the foliage and the more tender branches being shrivelled up and dead. I do not imagine, however, that the trees themselves will be destroyed; they will probably lose some two or three feet of their height and again flourish, if they escape a succession of severe winters.

"Were I to attempt—and I regret that I have not done

so—the cultivation of the eucalypti, I would arrange the plants in thick plantations, mixed with pines or nondeciduous trees, in order that the latter might afford protection to the young plants during their earlier growths. I find that the stokea, an Australian genus, grows perfectly well and is wholly unaffected by the winter climate of England: it would prove a good associate with the gum tree.

"Some twenty years since, on landing at Naples, and seeing so many plants of the Australian flora flourishing there, it occurred to me that the cultivation of the gum trees might be most advantageously followed throughout the whole of the Campagna. I tried to impress some of the official people in Rome whom I met with the idea, amongst others, Monsignor Talbot, whom I knew, and he engaged, if provided with the necessary supply of seed, that the experiment should be tried. At the cost of some trouble and expense, I procured a quantity of seed, sufficient by this time to have covered the whole Maremma and Pontine marshes with a forest of gum trees. But I believe the attempt in those good old days of Papal supineness was never made to initiate an experiment which, if successful, would transform the climate of Italy, and be of value in a thousand different ways.

"The coincidence of the presence of the eucalyptus and the infrequency of malaria is a most curious one. The investigation of the cause is one well worthy of pursuit."

In a second letter Sir Charles gives an account of the eucalyptus in India and New Zealand:

"In 1861 I went through India, and on visiting the Nilgherry hills was delighted to see the accacias, eucalypti and

angophorus growing, especially the first (the accacias) in the greatest luxuriance. I afterwards learnt from Sir William Denison (the then Governor of Madras) that many millions of plants had been established and were growing in different parts of the Presidency, and that the eucalyptus had been found to thrive on arid spots and places where no other trees could be grown. As a source of future supply for timber the cultivation of the eucalyptus is of course an object of the very highest importance. As you are probably aware, hundreds of thousands of acres of land that a few years ago in New Zealand were open downs or treeless plains, are now clothed with a thick forest of the indigenous trees (especially the eucalyptus) of Australia."

Annual General Meeting, April 18th, 1876.

EDWARD SCHUNCK, Ph.D., F.R.S., &c., President, in the Chair.

Mr. Robert Ellis Cunliffe, of Manchester, and Mr. Thomas Hornby Birley, of Somerville, near Manchester, were elected Ordinary Members of the Society.

Report of the Council, April, 1876.

The Treasurer's account shows that in consequence of the large outlay required for the repair and beautifying of the property, the renewal of upholstery, the charges for the incorporation of the Society, binding books, and a new catalogue, the expenditure for the year has been £324 11s. 11d. in excess of the income, and has diminished the balance to that amount; but the ordinary expenditure, allowing an average amount for binding and assistance in the library, would be within the income.

The ordinary balance is £94 8s. 7d., and there is due to the Society one year's rent from the Geological Society, which would make £125, less accounts owing for periodicals, £10, and voted for binding and not paid, £27, leaving an available balance of about £88.

The number of ordinary members on the roll of the Society on the 1st of April, 1875, was 169, and 3 new members have since been elected; the losses are—deaths, 2; resignations, 2; and defaulters, 2. The number on the roll on the 1st of April instant was, therefore, 166. The deceased members are Murray Gladstone and William Jackson Rideout.

Mr. Murray Gladstone, who died on August 23, 1875, was the fifth son of Robert Gladstone of Liverpool, where he

was born on the 14th of February, 1816. He was educated as an Engineer, being articled to the late George Stephenson. He followed this profession for several years, after which he became a member of the firm of Ogilvy Gillander and Co., and went to Calcutta, where he remained for several years. On the 30th April, 1861, soon after his return to England, Mr. Gladstone was elected a member of this Society. He then resided at Higher Broughton, at the house which is now Bishop's Court. He here set up an observatory with a $7\frac{1}{4}$-inch refracting telescope equatorially mounted. On the removal of the Crumpsall observatory to Altrincham Mr. Gladstone placed his observatory at the disposal of Mr. Baxendell. Some of the results of the observations made at this observatory have been published in the Society's Proceedings. On leaving Manchester he removed his observatory to his new residence, Penmaenmawr.

The Council having received a request from the Commissioners of the Loan Exhibition of Scientific Apparatus to contribute any interesting objects belonging to the Society, have, with the assistance of Dr. Roscoe, selected such of the late Dr. Dalton's apparatus and instruments as appeared to be of the greatest historical interest, and have sent the collection to South Kensington for exhibition.

The following papers and communications have been read at the ordinary and sectional meetings of the Society during the session now ending:—

October 5th, 1875.—"On a Glue Battery," by Dr. J. P. Joule, F.R.S., &c.

"On the Red Marls under Manchester," by E. W. Binney, F.R.S., V.P.

October 11th, 1875.—"On the Hybrid British Heath, Erica Watsoni, Benth.," by Charles Bailey, Esq.

October 12th, 1875.—"On a Source of Atmospheric Ozone," by Joseph Baxendell, F.R.A.S.

October 19*th*, 1875.—"On some Reactions of Bromine and Iodine," by Professor C. Schorlemmer, F.R.S.

"On some Bronze Coins found sixty years ago under a Peat Bog at Miserton Car, in Notts," by E. W. Binney, V.P., F.R.S.

"Notes bearing on Mathematical History," by Sir James Cockle, F.R.S., Corresponding Member of the Society.

"Note on the Temperature of the body during Physical Exertion," by M. M. Pattison Muir, F.R.S.E., Assistant Lecturer on Chemistry, Owens College.

November 2*nd*, 1875.—"On a Lead Pipe which had been transformed into Galena," by Peter Spence, F.C.S.

"On the principle of the Electro-Magnet constructed by Mr. John Faulkner," by Professor Osborne Reynolds, M.A.

November 8*th*, 1875.—"The Fauna of Cymmeran Bay, Anglesea, Part II.," by John Plant, F.G.S.

November 16*th*, 1875.—"On an Instrument for Measuring the Direct Heat of the Sun," by Professor Balfour Stewart, LL.D., F.R.S.

"On a Colorimetric Method for Determining Small Quantities of Copper," by Thomas Carnelley, B.Sc., F.C.S. Communicated by Professor H. E. Roscoe, F.R.S., &c., &c.

November 30*th*, 1875.—"On the Estimation of very small quantities of Lead and Copper," by M. M. Pattison Muir, F.R.S.E., Assistant Lecturer on Chemistry, Owens College.

"On certain circumstances which affect the Purity of Water supplied for Domestic Purposes," by M. M. Pattison Muir, F.R.S.E., Assistant Lecturer on Chemistry, Owens College.

December 14*th*, 1875.—"On a Sample of Peat from lagoons in the Sierra Madre in Mexico," by Professor Schorlemmer, F.R.S.

"On Graphic Methods of Solving Practical Problems," by Professor Osborne Reynolds, M.A.

"On Explosions of Fire Damp," by E. W. Binney, V.P., F.R.S.

"Chemical Notes," by M. M. Pattison Muir, F.R.S.E., Assistant Lecturer on Chemistry, Owens College.

December 28*th*, 1875.—"On the Utilization of the Common Kite," by Dr. Joule, F.R.S., V.P.

"On the Migration of Swallows," by E. W. Binney, V.P., F.R.S.

January 11*th*, 1876.—"Note on a Method of Comparing the Tints of Coloured Solutions," by J. Bottomley, D.Sc.

"On Explosions of Fire Damp," By Robert Rawson, Esq., Hon. Member of the Society.

January 17*th*, 1876.—"On the Life History of Lymexylon Navale," by J. Sidebotham, F.R.A.S.

"On Psammodius Sulcicollis'" by J. Sidebotham, F.R.A.S.

January 25*th*, 1876.—"Stannic Arsenate," by William Carlton, Williams, F.C.S.

February 8*th*, 1876.—"On the Natural Gas from the Gas Wells in Butler County, Pennsylvania," by Professor Sadtler, of the University of Pennsylvania. Communicated by Professor C. Schorlemmer, F.R.S.

"Notice of a recent discovery of a pre-Historic Burial Place, near Colombier, in Switzerland," by William E. A. Axon, M.R.S.L., &c.

"On the Granites of Ravenglass and Criffel," by Wm. Brockbank, F.G.S.

"On Boulder Stones in the Manchester Drift," by E. W. Binney, V.P., F.R.S.

"On the Formation of Azurite from Malachite," by Charles A. Burghardt, Ph.D.

"On a Direct-Vision Spectroscope of great Dispersive Power," by Arthur Schuster, Ph.D.

"On a New Absorptiometer," by Arthur Schuster, Ph.D.

February 14*th*, 1876.—On a New British Moss—Hypnum nitidulum (Wahl)," by Mr. James Percival.

"On the Gradual Decrease of Wild Birds during the last 25 years West of Manchester," by John Plant, F.G.S.

February 22*nd*, 1876.—"Notes on a Collection of Apparatus Employed by Dr. Dalton, in his Researches, which is about to be Exhibited (by the Council of the Literary and Philosophical Society of Manchester) at the Loan Exhibition of Scientific Apparatus, at South Kensington," by Professor Roscoe, F.R.S.

"On the Zoological Station and Aquarium at Naples," by Arthur William Waters, F.G.S.

"On Glacial Action in the Valley of the Weir, etc.," by Professor T. S. Aldis, M.A.

February 29th, 1876.—"An Account of some early Experiments with Ozone, and Remarks upon its Electrical Origin," by J. B. Dancer, F.R.A.S.

"Results of Rain Gauge Observations, made at Eccles, near Manchester, during the year 1875," by Thomas Mackereth, F.R.A.S., F.M.S.

March 7th, 1876.—"On Crystals of Sulphate of Lead found in Alum Residue," by R. S. Dale, B.A.

"On the Degree of Accuracy displayed by Druggists in the Dispensing of Physicians' Prescriptions in different towns throughout England and Scotland," by William Thomson, F.C.S.

March 13th, 1876.—"On a Series of Specimens of very young Rhombus Vulgaris (Cuv.)," by R. D. Darbishire, F.G.S.

"Notes made during a Visit in the past Summer to the Swedish Shell-beds of Uddevalla and the neighbouring district," by R. D. Darbishire, F.G.S.

"List of Shells found in Cymmeran Bay, Anglesea. Corrections and Additions," by John Plant, F.G.S.

March 21st, 1876.—"On a Graphical Method of Drawing Spectra," by Mr. William Dodgson, Whitworth Scholar. Communicated by Professor Roscoe, F.R.S., &c.

"Evidence to prove that a Bone from the Windy Knoll, Castleton, named by Professor W. Boyd Dawkins, F.R.S., 'Sacrum of young Bison,' is a Sacral Bone of the Cave Bear, Ursus Spelæus," by John Plant, F.G.S.

April 4th, 1876.—"On the Depreciation in the value of Silver," by Professor W. Boyd Dawkins, F.R.S.

"On some Isomerides of Alizarine," by Edward Schunck, Ph.D., F.R.S., and Hermann Roemer, Ph.D.

"Note on Mr. Plant's Fossil Sacrum from Windy Knoll," by Professor W. Boyd Dawkins, F.R.S.

"The Eucalyptus and Malaria, by Dr. R. Augus Smith, F.R.S., V.P.

"On the Eucalyptus," by Professor W. Boyd Dawkins, F.R.S.

Several of the above papers have been passed by the Council for printing in the Society's Memoirs. The printing of Vol. V., third Series, of the Memoirs has been completed, and the copies are now in the hands of the bookbinders.

The Council again consider it desirable to continue the system of electing Sectional Associates, and a resolution on the subject will be submitted at the annual meeting for the approval of the members.

The Librarian reports that since the last annual meeting a large number of volumes have been bound and the catalogue has been printed. The number of societies with which we correspond continues nearly the same as last year. Copies of the catalogue can be had by members on application.

On the motion of Dr. BORGHARDT, seconded by Mr. R. S. DALE, the Report was unanimously adopted, and ordered to be printed in the Society's Proceedings.

On the motion of Mr. BAXENDELL, seconded by Mr. BAILEY, it was resolved unanimously: —

That the system of electing Sectional Associates be continued during the ensuing Session.

The following gentlemen were elected officers of the Society and members of the Council for the ensuing year:

President.

EDWARD WILLIAM BINNEY, F.R.S., F.G.S.

Vice-Presidents.

EDWARD SCHUNCK, PH.D., F.R.S., F.C.S.
JAMES PRESCOTT JOULE, D.C.L., LL.D., F.R.S., F.C.S.
ROBERT ANGUS SMITH, PH.D., F.R.S., F.C.S.
HENRY ENFIELD ROSCOE, B.A., PH.D., F.R.S., F.C.S.

Secretaries.

JOSEPH BAXENDELL, F.R.A.S.
OSBORNE REYNOLDS, M.A.

Treasurer.

SAMUEL BROUGHTON.

Librarian.

FRANCIS NICHOLSON, F.Z.S.

Of the Council.

REV. WILLIAM GASKELL, M.A.
ROBERT DUKINFIELD DARBISHIRE, B.A., F.G.S.
WILLIAM BOYD DAWKINS, M.A., F.R.S.
BALFOUR STEWART, LL.D., F.R.S.
CHARLES BAILEY.
CARL SCHORLEMMER, F.R.S.

On the motion of Mr. HENRY H. HOWORTH, seconded by Mr. JOHN A. BENNION, it was resolved:

That the Council be requested to consider the amendment of the present imperfect system of election of officers of the Society.

On the motion of Mr. SPENCE, seconded by Dr. R. ANGUS SMITH, it was resolved unanimously:

That a Memorial be presented to the Mayor and Corporation of the city of Manchester expressing the regret of the Society to hear that it is proposed to transfer the Reference Library to the upper rooms of the new Town Hall, and urging the importance, in the interests of science and literature in Manchester, of having the valuable books of reference belonging to the city placed in a central locality in rooms which will afford the easiest possible access and large facilities for study.

THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

Balance Sheet from April 1st, 1875, to March 31st, 1876.

SAMUEL BROUGHTON, TREASURER.

Dr. **Cr.**

1875		£	s.	d.	£	s.	d.
April 1.–	To Balance from last Year				542	1	1
,,	*Members' Contributions:*						
	2 Arrears, Admission Fees, 1874-5	4	4	0			
	11 ,, Subscriptions ,,	23	2	0			
					27	6	0
	169 Members on Roll, at £2 2s.	354	18	0			
	Less Compounders 4)						
	,, in Arrear ..20) ,,	50	8	0			
					304	10	0
	3 Admission Fees, 1875-6 ,,	6	6	0			
	3 Subscriptions elected, 1875-6, at £2 2s.	6	6	0			
					12	12	0
	2 Associates, Microscopical Section				1	0	0
					345	8	0
,,	*Sale of Publications:*						
	Proceedings Sold				2	6	7
,,	*Sundry Income:*						
	Microscopical	2	2	0			
	Mathematical	2	2	0			
					4	4	0
	Geological Society, use of Room, 1874-5	30	0	0			
	Scientific Students ,, 1874-5	34	10	0			
	Society Promoting Female Education	13	15	0			
					78	5	0
	Bankers' Interest				8	16	0
							438 19 7
,,	Interest from the Owens College on £1500 Natural History Fund to December 25, 1875, less tax at 2d.						59 10 0
							£1040 10 8

	General Balance:						
	Compound Fund				98	15	0
	Natural History Fund, last year	24	5	7			
	,, ,, 1 yrs. Interest	59	10	0			
		£83	15	7			
	Voted for Books	40	0	0			
					43	15	7
	Other Balance				94	8	7
					£236	19	2

1876.		£	s.	d.	£	s.	d.
March 31.—By	*Charges on Property:*						
	Chief Rent	12	16	2			
	Insurance	7	0	0			
	Property Tax	5	13	4			
	Painting	33	5	8			
	Gasfitting	21	0	0			
	Repair of Roof, Re-flagging, and other Repairs	66	18	11½			
					146	14	1½
,,	*House Expenditure:*						
	House Tax	2	2	6			
	Water, Gas, Candles, and Coal	18	11	3			
	Cleaning and Petty Expenses	8	13	8			
	Tea and Coffee at Meetings	18	6	4½			
	Upholstering	44	9	3			
					92	3	0½
,,	*Administration Charges:*						
	Wages of Keeper of Rooms	57	4	0			
	Attendance on Sections and Societies	21	19	0			
	Postage and Parcels	18	10	1			
	Stationery and Circulars	12	16	0			
					110	9	1
,,	Law Charges for Incorporation of Society				81	5	10
,,	*Publishing:*						
	Memoirs and Engraving	50	0	6			
	Proceedings	38	1	0			
	Editor of Memoirs and Proceedings	50	0	0			
					138	1	6
,,	*Library:*						
	Periodicals	16	17	9			
	Binding	73	9	2			
	Shelving	3	5	0			
	Printing Catalogue	31	10	0			
	Assistance in Library and Compiling Catalogue	67	14	0			
	Subscription to Palæontographical Society, 2 years	2	2	0			
					194	17	11
	Total Expenditure				763	11	6
,,	Natural History Section for Purchase of Books				40	0	0
,,	Balance				236	19	2
					£1040	10	8

Examined and found correct, April 3, 1876.

W. A. CUNNINGHAM.
WM. BROCKBANK.

Ordinary Meeting, April 18th, 1876.

EDWARD SCHUNCK, Ph.D., F.R.S., President, in the Chair.

"Note on a Church Bell, at North Wooton, Somersetshire, dated A.D. 1265, in Arabic Numerals, and on a MS. dated A.D. 1276, in which they are freely used," by WILLIAM E. A. AXON, M.R.S.L., &c.

The date at which Arabic numerals were introduced into this country has been a matter of considerable doubt and discussion. There are very few to be found upon our monuments and public buildings earlier than the 16th century. Dates have frequently been cited, such as 1090, 1102, and so forth, but closer examination has proved that they have been misread. There is a doubtful date which may be 1417 given in the Archæological Journal, Vol. VI, p. 291. Heathfield church contains the date 1445, and Lych-gate, at Bray. Berkshire, is dated 1448. In documents the Arabic numerals are only occasionally met with in England in the fifteenth century, and only two examples are known belonging to the fourteenth century. Mabillon, after examining six thousand European MSS., found no earlier instance of the use of these figures than one of 1355, in the handwriting of Petrarch. Having written an article on the history of the Arabic numerals in the *Companion to the Almanac* for 1875, in which these dates were given, I received from Mr F. W. Dunkerton, an interesting rubbing of a bell inscription, which I now exhibit. The bell is in the church of North Wootton, near Wells, in Somersetshire,

The church is about seven miles from Glastonbury, and there is a local tradition that one of the bells once belonged to the famous abbey of that place. Mr. Dunkerton's curiosity being thus excited, he examined the bells. Two are modern, but the largest is an old one, and round it towards the top is this inscription :

ANNO DOMINNI AP. W.L. CW. 126ς.

The letters appear to be cast, and not incised.

If we were to accept this date as accurate, it would upset all our previous notions upon the subject. There are other reasons for regarding it with doubt. The earliest known English church bell is that at Claughton, near Lancaster, which is dated ANNO DOMI M.CC. NONOG. VI. (1296). The North Wootton date is thirty-one years earlier. It would be strange if the oldest bell should chance to be also the earliest example of the use of the Arabic numerals in English inscriptions. Dates are but rarely found on mediæval bells. The earliest instance of the use of Arabic numerals on them with which I am acquainted is at Egglingham church, near Alnwick. The inscription is in German, and the date 1489. Strasburg is said to have one bell dated 1461, and another 1474. There is therefore strong probability against the accuracy of this North Wootton date. The style of the letters remind one of a later period. Apart from the date, most persons would be inclined to attribute them at the latest to the 16th rather than the 13th century. The three sets of initials seem also to indicate a comparatively recent age. Mr. H. T. Ellacombe, in his work on the "Church Bells of Somersetshire," suggests that the date should be read 1625, the figures being out of order. This seems impro-

bable. Mr. Ellacombe does not appear to have seen the bell itself. The letters have a strong resemblance to those used by Roger Semson, of Ash Priors, who was at work in the middle of the 16th century.

The vine leaf ornament which is observable over the inscription suggests an even later date. It was a form of decoration frequently used by a family of bellfounders at Closworth, one member of which, Thomas Purdue, died in 1711, aged 90 years. The letters he used strongly resemble those employed by Semson.

Mr. J. A. Picton, F.S.A., who has paid a good deal of attention to the history of numerals, writes to me that he is inclined to identify the second figure with the gobar figure 5, though it differs in position, and the last figure with the gobar 4. In this case the date would be 1564. Whilst agreeing with him in assigning the inscription to the 16th or 17th century, I am unable to solve the riddle of the date in a satisfactory manner. It is certainly the most puzzling of all those which seem to carry back the use of Arabic numerals to a much remoter date than is commonly allowed. On this general subject, however, the last word has not yet been said. Since the publication of Mr. Picton's memoir "On the Origin and History of the Numerals" in the *Transactions of the Liverpool Literary and Philosophical Society*, 1874, and of my own paper in the *Companion to the Almanac*, 1875, we have both heard of a MS. of the 13th century, in which the Arabic figures are freely used. It is a treatise on the Astrolabe, by Macha-allah, or Messahala, and is dated 1276. This is now one of the treasures of the Cambridge University library, where it is marked Ii. 3.3.

A portion of it has been printed in the Rev. W. W. Skeat's edition of Chaucer on the Astrolabe (*Early English Text Society*, 1872.)

This shows that the Arabic numerals were in use at a date much earlier than is generally supposed. A critical examination of this MS. and of the form of the numerals employed would probably throw more light upon this interesting subject.

PHYSICAL AND MATHEMATICAL SECTION.

Annual Meeting, March 28th, 1876.

E. W. BINNEY, F.R.S., F.G.S., President of the Section, in the Chair.

ARTHUR SCHUSTER, Ph.D., and R. F. GWYTHER, B.A., were elected members of the Section.

The following gentlemen were elected officers of the Section for the ensuing year:—

President.

E. W. BINNEY, F.R.S., F.G.S.

Vice-Presidents.

JOSEPH BAXENDELL, F.R.A.S. | J. B. DANCER, F.R.A.S.

Treasurer.

SAMUEL BROUGHTON, ESQ.

Secretary.

THOMAS MACKERETH, F.R.A.S., F.M.S.

April 25th, 1876.

ALFRED BROTHERS, F.R.A.S., in the Chair.

Mr. BAXENDELL read a paper "On the Connexion between the Humidity of the Air and the Amount of Ozone," in which it was shown from observations made at the Southport Observatory during the four years ending June 30th, 1875, that in the months of January, February, March, September, October, November, and December the amount of ozone was above the mean when the relative humidity of the air was below the mean, while in the months of April, May, June, July, and August it was above the mean when the relative humidity was also above the mean. The excess with a relative humidity below the mean was greatest in the months of September, November, and December; and

with a relative humidity above the mean the greatest excess of ozone occurred in April and May. The results of the four years' observations are as follows:—

	Mean Amount of Ozone, with the Relative Humidity of the Air		
	Below the Mean.	Above the Mean.	Difference.
January	5·6	4·5	+1.1
February	4·8	3·9	+0·9
March	5·4	5·1	+0·3
April	4·0	5·7	--1·7
May	5·2	6·8	—1·6
June	5·2	6·2	—1·0
July	5·3	5·4	—0·1
August	4·9	5·1	—0·2
September	6·4	4·1	+2·3
October	5·0	3·7	+1·3
November	5·8	3·5	+2·3
December	5·8	3·7	+2·1

MICROSCOPICAL AND NATURAL HISTORY SECTION.

April 10th, 1876.

A. BROTHERS, F.R.A.S., in the Chair.

Mr. SIDEBOTHAM, F.R.A.S., made the following remarks.

On the discovery of Ægialia rufa.

In the middle of last June I captured two specimens of a species of Coleoptera new to me. This proves to be *Ægialia rufa* of Fabricius, a species found in North Germany, but said to be rare. *Rufa* differs from the other two British species in being of a red colour, the prothorax is rugose and margined at the base, and the elytra strongly crenate striate. The specimens found were on the loose sand at the base of the sand hills at Southport. I send one of the specimens for exhibition, also specimens of the other two allied species.

Mr. T. Rogers communicated the following:—

I recorded the discovery of a *Jungermannia* which has been provisionally named *Jungermannia Nevensis*, by Dr.

Carrington. It was discovered by Mr. John Whitehead during a botanical excursion to Ben Nevis, July, 1875. It has not yet been described, but is near in form to *Jungermannia Starkii*, and probably may have been overlooked for that species. Dr. Carrington thinks it may be new to science, but he confirms Mr. Whitehead's surmise that it is new to Britain, and it will consequently appear in the appendix to Dr. Carrington's work on British Hepaticæ. It grows in moderate sized patches on the sloping banks of the mountain. Neither male nor female flowers have yet been found.

Professor W. Boyd Dawkins, F.R.S., exhibited a series of specimens which he obtained in September, 1875, from the inner side of the barrier reef at Honolulu, together with photographs. At that point of examination the reef was formed of irregular nodular limestones composed in part of corals, millepores, and perfect shells, but mainly of fragments so broken up and altered by the action of carbonic acid that the original structure was almost lost. The fine calcareous sediment forming the bottom of the lagoon, and covering the shore up to the very edge of the lofty palms was analogous in every respect to that which composes the oolitic limestones, and especially the Bath or great oolite. In the deposits on the inner side of the reef, as well as in the limestones above mentioned, corals were equally distributed. The masses of coralline limestone were traversed by Serpulæ, just as in the case of the Coral Crag.

The few shells which he happened to find were as follows :—

	Range in British Museum.
1. *Triton Chlorostoma*, Lam.	... West Indies.
2. *Fasciolaria stigmataria*, A.Ad.	... Sandwich Isles.
3. *Purpura haustrum*, Martyn.	
4. *Nassa hirta*, Hil.	... Seychelles.
5. *Obeliscus teres* A.Ad.	... Penang.

	Range in British Museum.
6. *Cyprœa caput-serpentis*	... New Zealand.
7. *Cyprœa gangrenosa?* Sol.	... Mozambique.
8. *Trochus anthosa* (?) *tuberculata?* Gray.	... New Zealand.
9. *Natica Brodripiana?* Reclus	... West Columbia.
10. *Turbo margaritacea*, Lam.	... Seychelles.
11. *Tellina rugosa*	... New Caledonia.
12. *Myrtea scalia*, Lam.	... St. Thomas.
13. *Terna Californica?* Young. *Terna Cumingii?* Reeve.	
14. *Modiola tenuistriata*, Dun.	

It is worthy of note that the *Obeliscus teres* of the above list is the nearest living representative of the oolitic genus *Nerinœa* so abundant in the limestones of that formation.

The following communication from Mr. Plant, F.G.S., was read :—

A Beetle of Good Omen from Yucatan.

This curious beetle is found in the Province of Merida, and the Indians find it in the caverns and underground chambers in the ruins of the ancient buildings, described by by Mr. J. L. Stephens in his interesting work on Yucatan. The natives have a strong superstitious regard for these beetles, considering them as powerful charms against evil spirits, and sure to bring good luck to their possessors, so they keep them alive in their houses, and carry them about on their persons. In order to secure the beetle from wandering away, a light band of gold is fastened round the thorax, having a gold chain and hook attached to it; this hook serves to secure the beetle to the curtains of a bed, as a protection during the night from ghosts and evil spirits and also to fasten in front of the dress in the daytime, to wear like a living brooch. The Indians have a belief that the beetle will live for years without food or water, and

that it is quite harmless, having no power to bite, and cannot fly.

It is probable that in a natural state the beetle will live several years, as it belongs to a tribe of coleopterous insects of sluggish habits, concealing themselves in dark and damp places and shunning the daylight.

The whole of this tribe of beetles (Melasoma) is usually uninteresting to coleopterists, being nearly all of dull black, brown, or greyish colours, ugly in forms, and of bad repute for their habits and odours. This particular beetle is oblong, flattish, an inch and half long by half an inch broad (looking much like a large Elater), the thorax and elytra ashy white, a black cross on the thorax, the scutellum and tips of the elytra black, with raised oblong black spots, sparingly on the elytra which are united together underneath, black with numerous ashy pits.

The beetle is Heteromerous, coming under the family of Melasoma *(Latreille)*, in which the British *Blaps Mortisaga* is included, but I have not at present been able to find any authority for the genus and species.

It is an interesting instance of reverence and superstition attached to an insect, and coming from Yucatan, may be one that has descended from the ancient people who built those marvellous cities and temples.

Annual Meeting, May 1st, 1876.

JOHN BARROW, Esq., in the Chair.

Mr. Thomas Hornby Birley, of Somerville, Pendleton, was elected a member of the Section.

The Treasurer's account, and report of the Council were read and passed.

THE MICROSCOPICAL AND NATURAL HISTORY SECTION OF THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY

Dr. IN ACCOUNT WITH THE TREASURER, H. A. HURST. **Cr.**

1876.	£	s.	d.
To Murray's Manuals	1	8	0
„ Archives du Muséum	24	0	0
„ Nouvelles Archives	14	8	0
„ Ditto ditto	4	0	0
„ Bulletin de la Soc. Bot. de France	18	14	0
„ Adams on the Microscope	0	12	0
„ Sectional Subscription	2	2	0
„ Reaumur's Memoires des Insects	2	2	0
„ Ralf's Desmidieæ	3	13	6
„ Subscription for "Ibis" for 1876	1	1	0
„ Teas and Postages	4	8	7
„ Balance in Bank	91	3	4
	£167	12	5

Examined and found correct,

(Signed) EDWD. W. BINNEY, JNO. DALE, } AUDITORS.

H. A. HURST.

1875.	£	s.	d.
May 1.—By Balance at Bank	104	19	8
1876.—Subscriptions:			
One Arrear £0 10 0			
Seven Associates 3 10 0			
Thirty-four Members 17 0 0			
	21	0	0
Received on account of interest on Grant from late Natural History Society	40	0	0
Interest allowed by Bank to Dec., 1875	1	12	9
	£167	12	5

1876.

May. By Balance at Manchester and Salford Bank, St. Ann's-street £91 3 4

The election of Officers for the ensuing year took place as follows:—

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Williamson, Wm. Crawford, F.R.S., Prof. Nat. Hist., Owens College.
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Warren, Hon. J. B. Leicester.
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