MEMOIRS AND PROCEEDINGS

OF

THE MANCHESTER

LITERARY & PHILOSOPHICAL SOCIETY.

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NOTE.

The authors of the several papers contained in this volume are themselves accountable for all the statements and reasonings which they have offered. In these particulars the Society must not be considered as in any way responsible.

MEMOIRS AND PROCEEDINGS

OF

THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

Ordinary Meeting, October 4th, 1887.

FRANCIS NICHOLSON, F.Z.S., in the Chair.

Reference was made to the loss which the City and the Society had sustained through the death of the Society's new member, Mr. Charles Moseley, and to the material assistance which he had recently rendered to the Local Committee for the reception of the British Association in Manchester. Mr. Moseley made considerable sacrifices in endeavouring to maintain the Manchester Aquarium as a scientific institution, was instrumental in introducing and establishing telephonic communications in the City, and took an active part in organising the Manchester Jubilee Exhibition.

Mr. FARADAY mentioned that during a recent excursion (September) in the Belgian Ardennes he had seen a stuffed heron at Laroche, on the Ourthe, and, on inquiring if the bird was common in that locality, had been informed that it was only seen there in the winter—when it was abundant—but never in the summer months. He also alluded to the abundance of the thrush (French "Grive"), which was served at dinner in most of the hotels, and could be purchased for five centimes (one halfpenny) each.

The CHAIRMAN stated that no doubt the heron seen was of the same species as our common heron. In spring and in autumn there is a general shifting of the different species of birds going on from south to north and from north to south, not only amongst so-called migrants, but amongst species that are often considered to be residents. This movement takes place to a far greater extent than people who have not studied the subject would suspect. The common heron, or, as it is called in France and Belgium, "Héron huppé," is no exception to this rule, for as the spring advances it proceeds further north to its breeding quarters, and returns in the fall of the year, or when the hard weather comes on, to the south of Europe. Messrs. Degland and Gerbe, in their "Ornithologie Européenne," say:—"The common Heron *Ardea cinerea*, is found throughout the year in the vast marshes of Languedoc, Roussillon, and on the banks of the Rhône near its mouth," but probably the birds that are found in these localities in summer are birds that are not breeding in that particular year. The elevation of the Ardennes is nowhere very great, the valleys are sheltered, and the winter appears to be comparatively mild. As to the thrushes alluded to, they are most likely to be either the Fieldfare, "Grive litorne" of the French, or the Redwing, "Grive mauvis." Both these species visit the south of Europe in large flocks in the autumn from the north, where they breed in large numbers. The Redwing, *Turdus iliacus*, occurs during the winter and severe cold, in flocks, in company with the Fieldfare, *Turdus pilaris*, and they are much sought after for the table. The Redwing is a much smaller bird than the Fieldfare, but its flesh is more delicate in flavour.

Ordinary Meeting, October 18, 1887.

Professor BALFOUR STEWART, LL.D., F.R.S., President, in the Chair.

The President referred to the death of the Society's old member, Mr. Joseph Baxendell, F.R.S., F.R.A.S., for twenty-four years one of its secretaries and the editor of its publications up to his death, and stated that the Council had made arrangements for the preparation of an account of the deceased gentleman's life and work, and had passed a resolution expressing sympathy with Mrs. Baxendell in her bereavement. On the motion of Mr. H. H. Howorth, M.P., seconded by Mr. James Smith, it was resolved that a similar expression of sympathy should be forwarded from the Society.

Professor SCHUSTER alluded to the death of Professor Kirchoff, of Berlin, chiefly known for his work on the mathematical basis of Spectrum Analysis, and the author of many memoirs on various subjects of Mathematical Physics.

Mr. H. H. HOWORTH, M.P., directed the attention of the members to an old clock long preserved in the reading room of the Chetham College Library. It was presented by Nicholas Clegg in 1695, as appears from an entry in the donation book of the College. The clock has on it a barometer, which is still intact and is a very early example of the instrument. The barometer and a thermometer (now lost) are named with the clock in the notice of the gift.

Mr. JAMES COSMO MELVILL exhibited the original printed draft of Warren Hastings' "Defence," copiously annotated with marginal notes in the handwriting of the Right Hon. Edmund Burke, being the copy the great orator held in his hand at the time of his famous impeachment of the former Governor-General of India, in February, 1788. This most interesting M.S. was rescued from destruction during a general clearing out of old papers stored in the cellars of the old East India House in Leadenhall Street, London, by Mr. Melvill's grandfather, the late Sir James Cosmo Melvill, K.C.B., F.R.S., secretary of the H.E.I.C.S. for many years, from whom Mr. Melvill inherited it.

On the possible equations expressing the decomposition of Potassic Chlorate by Heat. By James Bottomley, D.Sc., B.A., F.C.S.

It has long been known that potassic chlorate when heated is resolved into oxygen, potassium chloride, and a more highly oxygenated product, potassium perchlorate, the equation expressing the change being usually written

$$2KClO_3 = KClO_4 + 2KCl + O_2.$$

Lately the decomposition of the salt has been investigated by Teed, and also by P. Frankland and Dingwall, their results being communicated to the Chemical Society. Teed, from his results, derives the equation

$$10KClO_3 = 6KClO_4 + 4KCl + 3O_2,$$

and in a second communication giving the results of experiments wherein the salt was more gently heated, he gives as a more approximate equation

$$22KClO_3 = 14KClO_4 + 8KCl + 5O_2,$$

P. Frankland and Dingwall derive from their results the equation

$$8KClO_3 = 2O_2 + 5KClO_4 + 3KCl.$$

The matter has also been discussed by Mills in the April number of the *Philosophical Magazine*. He there gives the following equation as expressing all known relations among those products :—

$$(1)\ 2nKClO_3 - (n-2)O_2 = (n+1)KClO_4 + (n-1)KCl.$$

Some years since I gave a general method for determining the coefficients in chemical equations (*Proceedings—Lit.*

& Phil. Soc.—Vol. xvii.). Suppose P molecules of $KClO_3$ to interact and give rise to Q_1 molecules of $KClO_4$, Q_2 molecules of KCl, and Q_3 molecules of O, then we shall have the equation

$$(2)\ PKClO_3 = Q_1KClO_4 + Q_2KCl + Q_3O_2$$

equating the coefficients of K on each side

$$P = Q_1 + Q_2,$$

the coefficients of Cl when equated give a similar equation. From the coefficients of O we derive the equation

$$3P = 4Q_1 + 2Q_2.$$

Hence we have four unknown quantities and only two equations. Substituting in (2) we get

$$(3)\ 2PKClO_3 = 2Q_1KClO_4 + 2(P - Q_1)KCl + (3P - 4Q)O_2$$

an equation containing two variables with the condition that P and Q are integers and 3P not less that 4Q. From the equation it is manifest that from the interaction of a given number of molecules of $KClO_3$ we may have several solutions of the equation : the number of solutions may be found by finding the largest integer in $\frac{3P}{4}$; an additional solution may be found if we admit *o* as a possible value of Q_1.

P = 11, the following equations are possible

$$\begin{aligned} 22KClO_3 &= 2KClO_4 + 20KCl + 29O_2 \\ &= 4KClO_4 + 18KCl + 25O_2 \\ &= 6KClO_4 + 16KCl + 21O_2 \\ &= 8KClO_4 + 14KCl + 17O_2 \\ &= 10KClO_4 + 12KCl + 13O_2 \\ &= 12KClO_4 + 10KCl + 9O_2 \\ &= 14KClO_4 + 8KCl + 5O_2\ (7) \\ &= 16KClO_4 + 6KCl + 1O_2 \end{aligned}$$

Of these (7) is the equator given by Teed.

If in (1) we make $n = 2$, the equation becomes

$$4KClO_3 = 3KClO_4 + KCl\ ;$$

if P = 2 in equation (3) we have

$$4KClO_3 = 4KCl + 6O_2,$$

and

$$4KClO_3 = 2KClO_4 + 2KCl + 2O_2$$

Equation (3) may be converted into equation (1) by writing $\frac{P(n+1)}{2n}$ for Q, *n* being a new variable, and then multiplying both sides of the equation by $\frac{n}{P}$. If in (3) we make $P=1$, we cannot derive the equation usually given without employing a fractional value ($\frac{1}{2}$) for Q. Can this imply that the equation is impossible, for can we have a fraction of a molecule? The arbitrary connections of P and Q may be shown as follows:—Collecting the terms involving P on one side and those involving Q on the other, we have

$$P \times (2KClO_3 - 2KCl - 3O_2) = Q \times (2KClO_4 - 2KCl - 4O_2),$$

or

$$P \times o = Q \times o.$$

Ordinary Meeting, November 1st, 1887.

Mr. JOHN ANGELL, F.I.C., F.C.S., in the Chair.

Professor SCHUSTER mentioned some experiments made by Prof. Hertz, of Carlsruhe, pointing to a curious effect of light in the electric discharge. It seems, according to these experiments, that when ultra-violet light is allowed to fall on spheres of metal between which electric sparks are produced, the sparks pass more easily and can be obtained of greater length.

Dr. HODGKINSON mentioned an electrical property of quartz which he had observed, and which, if established, prove the unsuitability of this substance as a covering medium for campasses, watches, and other magnetisable instruments.

Pasteur and Faraday : Note on Dr. Tyndall's Introduction to the English Edition of the "Histoire d'un Savant par un Ignorant." By F. J. Faraday, F.L.S.

It is not generally known that Faraday's latest attempt at experiment was in relation with the researches of Pasteur. During a recent conversation with Miss Jane Barnard, that lady informed me that she one day found her uncle engaged with certain vessels containing solutions which he was revolving and observing very attentively. He desired her to take great care of the apparatus, remarking that the inquiry was an important one in connection with the work of Pasteur. The incident occurred, however, during that closing period of Faraday's life for which he had himself prepared by warning those about him, that, when it had evidently arrived, his wishes were no longer to be treated as commands.

I am disposed to think that on the occasion in question the fading mind of our great philosopher had reverted to impressions produced at the time, twenty years before, when his own researches and those of Pasteur appeared to touch. The two groups of researches on the magnetisation of light and molecular dissymmetry respectively, are the subject of comment in Dr. Tyndall's introduction to Lady Claud Hamilton's translation of M. Radot's "Histoire d'un Savant par un Ignorant." Miss Barnard's story has led me to read again Dr. Tyndall's remarks, Pasteur's statement of his views on the phenomena of the rotation of the plane of polarised light by organic compounds, and Faraday's own paper on the magnetisation of light, forming the nineteenth series of the "Experimental Researches in Electricity." I venture to hope that a consideration of the opinions therein severally expressed may usefully occupy the attention of the Society.

In order to understand Pasteur's general idea it is necessary to follow the sequence of his researches. A student under Delafosse and Dumas, Pasteur plunged enthusiastically into the study of crystallography, at the time when Mitscherlich communicated to the Paris Academy of Sciences his discovery that two otherwise identical solutions, the tartrate and paratartrate of ammonia, had this difference, that the former rotated the plane of polarised light, while the latter, in this respect, was inert. Pasteur found that the apparently inert solution was really a compound of two acids, one of which rotated to the right and the other to the left, the opposing influences being neutralised in combination. Having been led to the discovery by observing the dissymmetry of the crystals, Pasteur inferred that the molecules of the solution are also built up on a dissymmetrical plan, and proceeding to examine a great variety of substances, he arrived at the conclusion that only those compounds which are the derivatives of life possess this molecular dissymmetry. In other words life alone, acting on matter, builds up dissymmetrical molecules, and of this molecular dissymmetry, the rotation of the plane of polarised light is the visible evidence.

In his endeavour to explain Pasteur's views, Dr. Tyndall states that in Pasteur's mind the agents of vitality are dissymmetric forces. It may be doubted whether this bare statement, though based on a passage in M. Radot's book, fully expresses Pasteur's idea. I believe that Pasteur would equally accept the statement that the ordinary or symmetrical forces of matter, acting under the control of the condition or agency called life, become dissymmetrical and result in dissymmetry. Pasteur seems to have an idea of a dissymmetrical influence which controls the *ensemble* of the universe, of which *ensemble* the "straight-line" forces of Dr. Tyndall are as much the elements as the substances we know as matter. Pasteur sees this influence expressed in the dissymmetric arrangement of the solar system, in the opposition of the north and south poles of the magnet, and in negative and positive electricity. Life, in his view, is a "function" of this "dissymmetrical influence." The fact that Pasteur, after the publication of Faraday's researches on the magnetization of light, endeavoured, by means of helices and magnets, to produce dissymmetrical crystals, seems to indicate that he did not regard the compounding of the forces under the direction of the experimentalist in such a way as to produce artificial dissymmetry as necessarily inconsistent with his law. Indeed Pasteur has himself expressed to M. Radot his belief in the possibility of the experimentalist passing the boundary between the mineral and organic derivative compounds by means of the introduction of "dissymmetrical influences." In this way Pasteur seems to expect that the chemists may produce the inverse of given organic substances, in other words that they may change right-handed into left-handed substances and *vice versâ*. Endeavouring to understand Pasteur's views, I see no reason why he should not interpret in his own way Dr. Tyndall's famous dictum:—"It is the compounding in the organic world of forces belonging equally to the inorganic that constitutes the mystery and the miracle of vitality." Adopting this generalisation, Pasteur might still point out that everything depends on the "compounding," and that in one case there is a dominant compounding influence or force, not present in the other case; the result of the operation of which is molecular dissymmetry. Pasteur's "profound separation" between organic and inorganic substances would still exist. The philosophy of Pasteur's definition is illustrated even in the evolution theory. For evolution depends upon the initial mystery of variation, and variation can scarcely be spoken of as due to a "straight-line" force; it is essentially a tendency to dissymmetry.

It is important to remember that all Pasteur's subsequent discoveries relating to the phenomena of fermentation and virulent diseases are directly the result of his conviction of this radical difference between organic and inorganic chemistry, springing out of his early researches into molecular arrangement. This fact alone should cause us to treat Pasteur's definition with very great deference. In Pasteur's mind it is the compounding influence which is life, while Dr. Tyndall's view would appear to be that life is the result of the compound—whether of forces or of matter we need not stop to inquire. Pasteur has always been pre-disposed to look for life as a cause; and in his view life is an influence apart, the product of nothing but itself.

Coming now to the discoveries of Faraday, Dr. Tyndall observes:—"If the turning of the plane of polarisation be a demonstration of molecular dissymmetry, then, in the twinkling of an eye, Faraday was able to displace symmetry by dissymmetry, and to confer upon bodies, which in their ordinary state were inert and dead, this power of rotation which M. Pasteur considers to be the exclusive attribute of life."

In this passage does not Dr. Tyndall lay himself open to the charge of assuming that analogous effects are necessarily due to identical states or causes, against which assumption Faraday, in his paper, expressly cautions his readers? To take a simple illustration: I may lift a bar of iron which may also be lifted by a magnet, but it does not follow that because in both cases the iron is raised, therefore the force which I exert is the same as that exerted by the magnet, or that the state of myself and of the magnet are the same. In comparing what Faraday himself calls "natural" and "artificial" rotation, let us assume the beam of light to be a ray of oscillating particles of ether. In passing through the organic compound which has the natural property of "rotating" the plane of such a ray, we may conceive the oscillatory motion of the light ray as taking the path of least resistance, and being, so to speak, twisted in consequence of the obstruction presented by the dissymmetrical arrangement of the atoms or molecules of the substance traversed, or, in other words, by the dissymmetrical nature of the path presented to it. If, now, Faraday's magnetic arrangement be introduced, we may further conceive of the oscillating ether particles being drawn aside to the lines of magnetic force as iron filings are drawn to such lines, the motion being in some way thus compelled to take a new plane. In this case, though the magnetic lines produced in the inorganic medium a twist or rotation of the plane, similar in appearance to the natural rotation in the organic substance, and intensified the rotation in the latter, it could not be said that the causes of the rotation, or the molecular states of the two substances in which the rotation took place, were identical.

It must be conceded, however, that Faraday appears to go a part of the way with Dr. Tyndall. Faraday tells us that he was satisfied that "the magnetic forces do not act on the ray of light directly and without the intervention of matter, but through the medium of the substance in which they and the ray have a simultaneous existence; the substances and the forces giving to and receiving from each other the power of acting on the light." This he considered he had proved by demonstrating the non-action of the forces in a vacuum, in air, and in gases; and that it was also further proved by the special degree in which different substances displayed the phenomena of rotation under the influence of the magnetic forces. If the action is direct and irrespective of the substance, then there appears no reason why the magnetic forces should not under all circumstances and in all substances affect the ray of light equally; and this is not so. Nevertheless Faraday contends that there is a direct relation, though matter is necessary for the action of that relation. "That magnetic force acts upon the ray of light always with the same character of manner, and in the same direction, independent of the different varieties of substance, or their states of solid or liquid, or their specific rotative force, shows," he says, "that the magnetic force and the light have a direct relation; but that substances are necessary and that these act in different degrees, shows that the magnetism and the light act on each other through the intervention of matter."

Moreover, it is clear that Faraday held that the magnetic influence effected some change in the state of the matter, of which the rotation of the ray was a symptom. "It cannot be doubted," he goes on to say, "that the magnetic forces act upon and affect the internal constitution of the diamagnetic just as freely in the dark as when a ray of light is passing through it, though the phenomena produced by light seem, as yet, to present the only means of observing this constitution and change." Further, he adds, "any such change as this must belong to opaque bodies, such as wood, stone, and metal, for as diamagnetics there is no distinction between them and those which are transparent." And then, proceeding to point out that the substances in question are not made into magnets, he remarks that the "molecular condition" of these bodies, when in the state described, must be a "new magnetic condition" distinct from that of magnetized iron, and that the force which the matter in this state possesses must be "a new magnetic force," or "mode of action" of matter.

Now, accepting this exposition of Faraday's, I submit that we are still a long way from being justified in assuming that the induced state of the substance is, as Dr. Tyndall assumes, the result of a displacement of symmetry by Pasteur's molecular dissymmetry; or that the fact that a new mode of action on light is induced, which resembles the natural rotatory influence of organic compounds, in any way invalidates Pasteur's provisional generalisation, that the natural rotation is an unfailing expression of a molecular condition produced only in the laboratory of life. In the first place it must be borne in mind that the state induced by the magnetic force is a state of tension which disappears instantly the magnet is removed; the state of molecular dissymmetry is not a state of tension, but the permanent state of the molecules themselves, requiring no outside sustaining influence. The rotatory power of the magnetized substance is exerted in only one general direction, that of the line of magnetic force; pass the beam of light through the substance in any other direction and it will be unaffected. The rotatory power of the natural state is exerted in every direction, the only limitation being that the rotation is always in the given substance either to the right or left of the observer. With this limitation the natural substance will simultaneously rotate the plane of rays of light which are passing through it in all directions. All this is clearly pointed out by Faraday. "The direction of the rotation produced by the natural state," he observes, "is connected invariably with the direction of the ray of light; but the power to produce it appears to be possessed in every direction and at all times by the particles of the fluid; the direction of the rotation produced by the induced condition is connected invariably with the direction of the magnetic line or the electric current, and the condition is possessed by the particles of matter, but strictly limited by the line or the current, changing and disappearing with it." I submit that the molecular condition of a substance which at a given time, under tension only, can exert a given power in only one direction is not the same as that of a substance which at any moment, without tension, can exert the power in every direction. The difference appears as profound as that between the limited motion of the steam-engine and the infinite mobility of the living organism.

I have been induced to indulge in this criticism (which I offer with every proper sentiment of modesty) by a conviction that the present-day tendency to round off the scheme of the universe and sum up the nature of things in a few simple generalisations, based on apparent analogies, is a real danger to the progress of science. It has recently been declared on high authority that "life is governed by chemical and physical forces even though we cannot in every case explain its phenomena in terms of these forces." A generalisation which avowedly fails to explain all the phenomena should be regarded with suspicion; and I think that in the future, as in the past, discovery is still likely to reward those who allow at least equal probability to the converse statement, which is more in accordance with the Pasteurian philosophy: that chemical and physical forces are governed by life.

MICROSCOPICAL AND NATURAL HISTORY SECTION.

Ordinary Meeting, October 10th, 1887.

Mr. THOS. ROGERS in the Chair.

Reference was made to the death of Mr. Joseph Baxendell, a member of the section and at one time President. A resolution was adopted directing the Hon. Secretary to write to Mrs. Baxendell, and express the sympathy of the members and associates.

Mr. JAMES CASH, Sale, and Mr. THOS. NOTON, Urmston, were elected associates.

Mr. P. CAMERON exhibited a parasite from the Hessian fly.

Mr. H. HYDE showed some skeletonized leaves prepared by maceration.

Under the microscope Mr. FLEMING exhibited the fresh-water Polyzoa *Paludicella christata;* and Mr. MOSS a number of sections of various ferns.

General Meeting, November 16th, 1887.

Professor BALFOUR STEWART, LL.D., F.R.S., President, in the Chair.

Mr. JOHN J. ASHWORTH, of Manchester, was elected an ordinary member.

Ordinary Meeting, November 16th, 1887.

Professor BALFOUR STEWART, LL.D., F.R.S., President, in the Chair.

On behalf of the members, the PRESIDENT presented to Mr. William Roscoe a silk purse containing forty sovereigns (a special donation of five pounds from the Microscopical and Natural History Section being included), on the occasion of Mr. Roscoe's retirement from the service of the Society as its house-keeper. It was intimated that an engrossed copy of the vote of thanks to Mr. Roscoe, passed at the last Annual Meeting, would be forwarded to him.

On the Electrical Attraction of Quartz, and the unsuitability of this substance as a protecting medium for compasses, watches, &c. By Alex. Hodgkinson, M.B., B.Sc.

Quartz, like most other substances, becomes electrified by friction, and also possesses the property of remaining in an electrified condition for a period varying from ten minutes to half an hour after the friction has ceased. When this medium is used as a cover for compasses, this electrical property may manifest itself in such a marked manner as to render the readings of the instrument utterly unreliable, and more especially is this the case where the instrument is provided with a quartz cover back and front. In the compass exhibited the back and front of the instrument consist of two plano-convex lenses of quartz with their plane surfaces towards each other, the needle rotating between these covers on an axis, the extremities of which fit into two conical holes in the centre of the quartz covers. In the case of this instrument, the mere act of removing it from the warm pocket is usually sufficient to cause the needle to assume a fixed position in relation to the compass itself and quite unaffected by the magnetic attraction of the earth. If, whilst in this condition, the instrument is rotated, the needle also rotates as if a fixture. If the surface of the quartz be rubbed with the dry finger in a radial direction the needle at once takes up a position in the same direction, and if compelled by shaking to change its position it resumes it when allowed to remain at rest. When the compass is so turned that the axis of the needle is in the direction of the magnetic force of the earth, and the needle therefore in equilibrium, the effects of radial friction become still more marked. As might be expected, the property is not confined to quartz. A compass covered with glass exhibited the same phenomena, with the important difference that in this case the attractive influence ceased with cessation of the friction. That the attractive influence is quite independent of the magnetic force of the needle is proved by the fact that an instrument similar in every respect to the first-mentioned instrument, excepting that the needle was left unmagnetised, exhibited the same phenomena. The action is therefore one of simple eletrical attraction.

MICROSCOPICAL AND NATURAL HISTORY SECTION.

Ordinary Meeting, November 7th, 1887.

Professor W. C. WILLIAMSON, LL.D., F.R.S., President of the Section, in the Chair.

Mr. R. D. DARBISHIRE sent for exhibition some remarkable seed vessels of *Martynia proboscidea* from La Plata, which had been imported entangled in fleeces.

Mr. H. HYDE showed a specimen of *Salaginella lepidophylla*, a dried plant which has the property of opening out when immersed in water, as though living.

Mr. T. SINGTON exhibited a fine antler of the Red deer, *Cervus elaphus*, and a horn of the Celtic short-horn, *Bos longifrons*, from the excavations for the Preston docks.

Mr. H. C. CHADWICK exhibited a number of specimens of *Asterias hispida*, the *Uraster hispida* of Forbes, which he had dredged from a depth of ten fathoms in the Menai Straits, off Bangor. Having studied the characters by which Forbes distinguished this species from his *Uraster rubens*, he had come to the conclusion that they were nothing more than the transient characters of the young of the latter species, a conclusion supported by the fact that the characters of the two species might be seen side by side in the larger specimens. He also exhibited a young specimen of an Ophiurid, *Ophiothrix fragilis*, the *Ophiocoma minuta* of Forbes, from the above-mentioned locality. Dr. ALCOCK mentioned that he had found it buried in sand at Red Wharf Bay.

Ordinary Meeting, November 29th, 1887.

Professor BALFOUR STEWART, LL.D., F.R.S., President in the Chair.

The PRESIDENT alluded to the paper on the derivation of the heavenly bodies from meteorites, recently read by Mr. Norman Lockyer before the Royal Society, and spoke of it as likely to prove a useful working hypothesis. A brief discussion ensued.

The effect of the small variation of the density of the atmosphere on the amplitude of plane waves of Sound approaching the earth. By Ralph Holmes, B.A.

In considering the motion of plane waves of sound through a medium of slowly varying density, supposing that no considerable alteration of density occurs within a distance of a great many wave lengths, it is customary to neglect all considerations of a reflected wave at any part of its course, and so to assume that the energy of the motion must remain unchanged. From this hypothesis we may deduce that the amplitude of vibration varies inversely as the square root of the density. Since, however, there is a reflected wave at every part of its course, it has appeared to me advisable to obtain an approximate value for its amplitude, and to compare its value with that of the progressive wave that we may obtain some more definite idea of the quantity we are neglecting. In the following paper

I have obtained as an approximation to the amplitude of the progressive part, due to the wave

$$\xi = \text{H}\cos\frac{2\pi}{\lambda}(at - x)$$

set up at a region where the density is D_0 the expression

$$\text{H}\sqrt{\frac{\text{D}_o}{\text{D}}}\left\{ 1 + \frac{1}{2}\text{A}^2\lambda^2\sin^2\frac{2\pi z}{\lambda} \right\}$$

while the amplitude of the retrograde wave is

$$\text{H}\sqrt{\frac{\text{D}_o}{\text{D}}}\text{A}\lambda\sin\frac{2\pi z}{\lambda}$$

where $\text{A}\lambda$ is extremely small.

Let us suppose that A and B are two planes of constant density at some little distance apart, and that at A, the progressive part of a wave travels towards B, through the slowly varying gas between; then at every part of its course we have a reflected wave so that the progressive part which passes B is not exactly the same as it would have been, if the gas between A and B and beyond B had been absolutely uniform. If we were to consider, however, that the density between the planes was allowed to become uniform so that the change of density at B would be sudden, then the same wave passing A would travel unchanged to B, part being reflected there, while the progressive wave passing B would differ infinitesimally from the progressive wave passing B when the gas varies continuously. These considerations will guide us in the discussion of the problem in hand.

Let .... A_{s-1} A A_{s+1} .... be planes of constant density, the difference of density at any two consecutive planes being excessively small, and suppose that all bodily forces producing the variation of density are annihilated, the planes being prevented from consequent motion by properly applied surface forces. Gravity is here supposed to be the cause of the variation and acts in the direction A_{s-1} A_s.

Then if P_{s-1} is the uniform pressure between A_{s-1} A_s the force required per unit area on the plane A_s is $P_s - P_{s-1}$.

We may notice that P_{s-1} is the actual pressure in the original state of the gas at some point between A_{s-1} A_s.

Let $0x$ be taken normal to the planes . . . $A_{s-1}A_s$ . . . and suppose that in some one of the compartment plane waves of sound of a given period are set up, the direction of propagation being $0x$.

Let x_s be the equilibrium distance of a normal plane in the compartment A_sA_{s+1} from the equilibrium position of the plane A_s,

$x_s + \xi_s$ the disturbed position due to the wave motion,

P_s, D_s the pressure and density in equilibrium,

p_s, ρ_s the pressure and density at the disturbed position of the plane x_s when there is wave motion. Then for the compartment A_sA_{s+1} we arrive at the ordinary equations of wave motion, viz. :—

$$\frac{d^2\xi_s}{at^2} = a_s^2 \frac{d^2\xi_s}{at^2} \quad . \; . \; . \; . \; \text{i.}$$

$$\rho_s = \frac{D_s}{1 + \frac{d\xi_s}{dx_s}} \quad . \; . \; . \; . \; \text{ii.}$$

If z_s be the distance of the plane A_s from the origin, and l_s be the distance between the planes A_s A_{s+1}, then a solution of (i.) which holds for all values of x_s between o and l_s may be written

$$\xi_s = (C_s\cos nt + B_s\sin nt)\sin m(z_s + x_s)$$
$$+ (C_s'\cos nt + B_s'\sin nt)\cos m(z_s + x_s)$$

where c_s, &c., are constant between $x_s = o$ and $x_s = l_s$. By changing the suffixes we may write the solution for any other compartment.

At the surface of separation of any two compartments, say A_{s+1}, we have the condition of equal velocities, viz. :—

$$\left(\frac{d\xi_{s+1}}{dt}\right)_{x_{s+1}=0} = \left(\frac{d\xi_s}{dt}\right)_{x_s = l_s}$$

which must hold for all values of the time.

Substituting for ξ_s and ξ_{s+1} and equating coefficients of $\cos nt$ and of $\sin nt$ we get

$$C_s \sin mz_{s+1} + C_s' \cos mz_{s+1} = C_{s+1} \sin mz_{s+1} + C_{s+1}' \cos mz_{s+1} \quad \ldots \text{(iii)}$$

and a similar equation for the B's.

We have also another surface condition, viz.: that of pressure, which gives us for all values of the time

$$P_s \left(\frac{d\xi_s}{dx_s}\right)_{x_s = l_s} = P_{s+1} \left(\frac{d\xi_{s+1}}{dx_{s+1}}\right)_{x_{s+1} = o}$$

from which we obtain

$$P_s \{C_s \cos mz_{s+1} - C_s' \sin mz_{s+1}\} = P_{s+1} \{C_{s+1} \cos mz_{s+1} - C_{s+1}' \sin mz_{s+1}\} \quad \ldots \text{(iv.)}$$

and a similar equation for the B's.

Hence from these two equations (iii.) and (iv.) we can determine C_{s+1}; C_{s+1}' in terms of C_s; C_s' and so in terms of C_o; C_o'.

Now the constants C_{s+1}, C_{s+1}' must be expressible as some function of the compartment to which they belong and hence must be some function of the density of that compartment. Hence since the difference of density between any two compartments is extremely small we may write

$$C_s = C_{s+1} - \frac{dC_{s+1}}{dD_{s+1}} \triangle D_{s+1}$$

$$C_s' = C_{s+1}' - \frac{dC_{s+1}'}{dD_{s+1}} \triangle D_{s+1}$$

$$P_s = P_{s+1} - \frac{dP_{s+1}}{dD_{s+1}} \triangle D_{s+1}.$$

Where $\triangle D_{s+1}$ is the small change of density, its square and higher powers being negligible.

If we substitute these values in equations (iii.) and (iv.) and neglect small quantities we obtain the equations

$$\sin mz \frac{dC}{dD} + \cos mz \frac{dC'}{dD} = 0$$

$$P\left(\frac{dC}{dD}\cos mz - \frac{dC'}{dD}\sin mz\right) + \frac{dP}{dD}\left(C\cos mz - C'\sin mz\right) = 0$$

or since $\frac{d}{dD}$ occurs in each term, these may be written

$$\sin mz\frac{dC}{dz}+\cos mz\frac{dC'}{dz}=0$$

$$P\left(\cos mz\frac{dC}{dz}-\sin mz\frac{dC'}{dz}\right)+\frac{dP}{dz}(C\cos mz-C'\sin mz)=0.$$

Now $P=kD$; we have therefore to consider the value of the differential coefficient $\frac{dP}{dz}$.

As stated above P is the pressure at some point between the planes A_{s+1} A_{s+2} in the actual state of the gas, from which we immediately obtain $\frac{dP}{dz}=gD$.

Thus our equations for C and C' become, writing y for mz,

$$\left.\begin{array}{l}\sin y\frac{dC}{dy}+\cos y\frac{dC'}{dy}=0,\\ \cos y\frac{dC}{dy}\sin y\frac{dC'}{dy}+h(C\cos y-C'\sin y)=0,\end{array}\right\}$$

where $h=\frac{g}{mk}$.

If in these equations we put

$$C=P\sin y+\cos y\frac{dP}{dy}$$

$$C'=P\cos y-\sin y\frac{dP}{dy}$$

the first is satisfied identically, while the second becomes

$$\frac{d^2P}{dy^2}+h\frac{dP}{dy}+P=0.$$

the solution of which is

$$P=e^{\mu y}(A\cos\nu y+B\sin\nu y),$$

where $\mu\pm\nu\sqrt{-1}$ are the roots of

$$x^2+hx+1=0$$

and h^2 is supposed for the moment less than 4.

The values of B and B' differ only from those of C and C^1 by containing different constants. If then we substitute the values found in the expression for ζ, noticing that

$\mu^2+\nu^2=1$ so that we may put $\cos\theta=\mu$, $\sin\theta=\nu$; after a little reduction we obtain

$$\zeta=\cos mx, e^{\mu mz}\{A\cos nt\cos(\nu mz-\beta)+A'\sin nt\cos(\nu mz-\beta')\}$$
$$+\sin mx e^{\mu mz}\{A\cos nt\cos(\nu mz-\beta-\theta)+A'\sin nt\cos(\nu mz-\beta'-\theta)\}$$

when A, A′, β, β' are absolute constants.

Now suppose that in the compartment at the origin we have the motion given by

$$\zeta=H\cos(nt-mx).$$

Applying this condition to determine the constants, we obtain for the motion in a compartment distant z from the origin

$$\zeta=He^{\mu mz}\left\{\cos\nu mz\cos(nt-mx)-\frac{\sin\nu mz}{\sin\theta}\sin(nt-mx)\right.$$
$$\left.+\cot\theta\sin\nu mz\cos(nt+mx)\right\}$$

But from the equations

$$\frac{dP}{dz}=gD$$
$$P=KD$$

we get

$$D=D_0e^{\frac{g}{K}z}=D_0e^{-2\mu mz}$$

so that

$$e^{\mu mz}=\sqrt{\frac{D_0}{D}}.$$

Thus finally we obtain

$$\zeta=H\sqrt{\frac{D_0}{D}}\left\{\cos\nu mz\cos(nt-mx)-\frac{\sin\nu mz}{\sin\theta}\sin(nt-mx)\right.$$
$$\left.+\cot\theta\sin\nu mz\cos(nt+mx)\right\}\quad\ldots\text{ v.}$$

This solution will allow us to obtain a very good idea of the changes which a sound wave undergoes when travelling through the continuously varying atmosphere, and will serve us to show how extremely small is the error in the ordinary approximation where we suppose there is no reflected wave.

Examining the solution v. we notice that it consists partly of a progressive and partly of a retrograde wave, of which the amplitude of the former is

$$H\sqrt{\frac{D_o}{D}}\left\{\cos^2\nu mz + \frac{\sin^2\nu mz}{\sin^2\theta}\right\}^{\frac{1}{2}},$$

while that of the latter is

$$H\sqrt{\frac{D_o}{D}}\cot\theta\sin\nu mz.$$

We will now show that the solution given satisfies the equation of energy. In the wave

$$\zeta = H\cos(nt - mx)$$

the work transmitted across unit area in time t is

$$W = \frac{1}{2}D_o\frac{n^3}{m}H^2t.$$

We will now obtain the expression for the work transmitted across unit area in time t, in the wave

$$\zeta = H\sqrt{\frac{D_o}{D}}\left\{\cos\nu mz\cos(nt - mx) - \frac{\sin\nu mz}{\sin\theta}\sin(nt - mx) + \cot\theta\right.$$
$$\left.\sin\nu mz\cos(nt + mx)\right\}$$

If P be the pressure and δP the variation of pressure

$$\frac{dw}{dt} = (P + \delta P)\dot{\zeta}$$
$$= \frac{1}{2}H^2D_o\frac{n^3}{m}\left\{\cos^2\nu mz + \frac{\sin^2\nu mz}{\sin^2\theta} - \cot^2\theta\sin^2\nu mz + \right.$$
$$\left. \ldots \text{periodic terms}\right\}$$
$$= \frac{1}{2}H^2D_o\frac{n^3}{m}\left\{1 + \text{periodic terms}\right\}$$
$$\therefore W = \frac{1}{2}H^2D_o\frac{n^3}{m}t$$

which shows that the condition of energy is satisfied.

Let us now consider the value of the small quantity h^2 and show that it is less than 4.

We have

$$h = \frac{g}{mK} = \frac{g\lambda}{2\pi K}$$
$$\therefore h = \frac{g\lambda\gamma}{2\pi v^2}$$

where v is the velocity of sound γ is 1·410.

$$\therefore h = \frac{g\gamma}{2\pi v \times \text{number of vibrations per second.}}$$

If we take the number of vibrations to be 550 per second, and the velocity of sound to be about 1100 feet per second, we obtain

$$h = \frac{32{\cdot}2 \times 1{\cdot}41}{2\pi \times 1100 \times 550} = {\cdot}000012,$$

so that

$$\mu = -{\cdot}000006,$$
$$\nu = \sqrt{1 - ({\cdot}000006)^2},$$

thus

$$\cot\theta = -{\cdot}000006,$$
$$\frac{1}{\sin^2\theta} = 1 + \frac{1}{2}({\cdot}000006)^2.$$

From these results we draw the following conclusions: that when plane waves of sound are travelling through the atmosphere and partially reflected at every part of their course, the amplitude of the progressive part differs by a few thousand-millionths of what it would have been if we supposed that the wave progressed without the slightest reflection; and if, instead of considering the reflected waves which occur at every part of the course for a number of wave lengths, we considered the reflected wave as being caused by a sudden change of density, then the amplitude of the retrograde wave would be about a millionth part of the progressive wave.

The method employed above seems unnecessarily artificial, but it has enabled me to obtain a result in some subsequent work which, I believe, is not only new, but correct, viz., that when the atmosphere is also supposed to be in a state of "convective" equilibrium the amplitude of a descending wave varies inversely as the power $\frac{\gamma + 1}{4}$ of the density.

MICROSCOPICAL AND NATURAL HISTORY SECTION.

Ordinary Meeting, December 12th, 1887.

Professor WILLIAMSON, LL.D., F.R.S., President of the Section, in the Chair.

Mr. EDWARD PYEMONT COLLETT, F.E.S., was elected an associate.

Mr. P. CAMERON, F.E.S., exhibited,—a fine collection of Indian Hymenoptera;

Mr. SINGTON,—Resin containing insects, from Zanzibar;

Mr. H. C. CHADWICK,—Two Armed Bull-heads, *Aspidophorus Europæus*, taken by him in the dredge in the Menai Straits; also, under the Microscope, a stained specimen of the Medusa, *Oceanea conica*.

The PRESIDENT showed living plants of *Salaginella pilifera*, and *Salaginella lepidophylla*, and described their specific differences and fructification.

Ordinary Meeting, December 13th, 1887.

Professor OSBORNE REYNOLDS, LL.D., M.A., F.R.S., Vice-President, in the Chair.

The CHAIRMAN referred to the death of the Society's honorary member, Mr. J. B. Dancer, F.R.A.S., and Mr. Faraday (one of the Secretaries) reported that he had been waited upon by Mr. Abel Heywood, Junr., and Mr. H. H. Howorth, M.P., with a request that he would bring to the notice of the Society the desirableness of an effort being made to obtain a grant from the Civil List for Mrs. Dancer. Thereupon—

It was moved by Mr. R. F. Gwyther, M.A., seconded by Mr. Harry Grimshaw, F.C.S., and resolved, "That the Officers of the Society be requested to consider, and, if possible, to further the application for a grant from the Civil List in behalf of the widow of the late Mr. J. B. Dancer."

Professor HORACE LAMB, M.A., F.R.S., made a short verbal communication on reciprocal theorems in dynamics. He called attention to a theorem recently given by Helmholtz, which appears to include as particular cases almost all the reciprocal relations as yet discovered in Dynamics, and gave several illustrations from Optics and Acoustics. In particular he referred to the principle of acoustic reversibility formulated long ago by Helmholtz, to the effect that if A and B be any two points in a homogeneous atmosphere at rest, the sound-intensity at B due to a source at A is equal to the intensity at A due to an equal source at B. The case when the air is in motion does not come under the principle as here stated; and in fact if B be to the leeward of A, the intensity is greater in the first case than in the second. The theorem referred to shows, however, that the reciprocity still holds, provided that when we transfer the source from A to B we also reverse the wind.

Memoir of the late Joseph Baxendell, F.R.S., F.R.A.S. By James Bottomley, D.Sc.

Joseph Baxendell was born April 19th, 1815, at Bank Top, Manchester. He was the son of Thomas Baxendell, an intelligent man, who by his own exertions raised himself from humble life. The family consisted of six sons and two daughters. Of his mother, whose maiden name was Mary Shepley, it is related that she had a strong love of observing the heavenly bodies, knowing well the planets, and many of the principal constellations; to this source probably may be traced Mr. Baxendell's life-long devotion to astronomy, early impressions giving to the mind, while yet supple and tender, a bent which remains to old age. His early years were spent at his parents' farm at Smedley, but agriculture was not his destiny, and, later on, a churn from the old farm served him as the most suitable round table on which to grind and polish specula for telescopes for himself and some early scientific friends. He was educated by Mr. Whalley, of Cheetham Hill, a man of some scientific attainments. He proved himself a rapid learner, and soon acquired all that his teacher could impart; to a large extent we may consider him as self-taught. If there had been then the opportunities now offered by the city for instruction in experimental science, possibly there might have been developed a capacity for experimental enquiry which would have been serviceable in some branches of his work. He does not seem to have devoted much time to experiment, and he was destined to develope into the accurate observer of phenomena, and the deducer of laws from laborious calculations. From his bent for mathematics, one may reasonably infer that a brilliant mathematician would at this time have found in him an apt pupil, and yet again, a possible advantage might not have been without some detriments, and excursions into the domains of pure mathematics would have left less time for astronomy and meteorology. We are liable to imagine that a man who has done well, would have done better under more favourable circumstances in his early career, but this is far from certain, and of one who has won for himself an eminent position with little extraneous assistance, we may with good reason say that it was best as it was. His constitution in early life was delicate, frequent visits to Southport with his mother for the sake of health led also to a love for a seafaring life; at first the fishing boats gave him an opportunity of gratifying his enthusiasm; afterwards, when about 14 years old, he embarked on board the ship Mary Scott, bound for Valparaiso. This step was taken in the hope that the voyage would invigorate his delicate constitution. Although so young, his excellent seamanship soon won the entire confidence of his Captain. It was his fortune to be a witness of the extraordinary display of meteors in 1833; he was well adapted to be the spectator of such a magnificent scene, being not wholly lost in admiration, but seeking to determine the radiant point from which they diverged. He also, while out at sea, experienced the shock of the earthquake in 1835, which was attended with such disastrous results to the Pacific coast of South America. He made several voyages, and when he retired, it was with no disgust of a maritime career, indeed in his old age, he would still speak with enthusiasm of the sea and the sailor's life.

After returning to Manchester, he was for some time engaged in assisting his father in his business. For some years he resided at Stocks Street, Cheetham, and afterwards at Crescent Road, Cheetham Hill. Here he was not far from the Observatory belonging to his friend Robert Worthington, situated in the pleasant park-like grounds attached to Crumpsall Hall. An accident to his right eye debarred Mr. Worthington from using his own Observatory; Mr. Baxendell had the privilege of using it, and the excellent work done therein, until its removal in 1869, won for it a distinguished place amongst private observatories, and engaged Mr. Baxendell in correspondence with the most eminent astronomers both in this country and abroad. Amongst other astronomical friends with whom he corresponded was Mr. Norman Pogson, Government Astronomer of Madras, and this connection became a closer one by the marriage of Mr. Baxendell with Mr. Pogson's sister Mary Anne in 1865; the issue of the marriage was an only son. His quiet orderly life offers little to be recorded. In his own town he was not widely known, nor did he ever seek to become widely known; indeed he furnishes a fresh instance of a peculiarity of scientific life in Manchester, that is the seclusion, almost bordering upon obscurity, of some of its most eminent men. Of Dalton it is stated by one of his biographers, "As is usually the case, on the death of an eminent man, the first proof is furnished to many persons that he was once alive."

Personal intercourse with Mr. Baxendell would leave the impression of amiability of disposition, and of a simplicity of character which has often been found associated with scientific eminence. Sometimes his communications would involve him in argument; on such occasions his views, when correct, were stated so quietly, and with such an absence of elation, that an adversary felt no wound. With regard to new theories, he was sometimes slow of conviction; no doubt the very nature of his studies had impressed upon him the extent of human fallibility, and the necessity of sifting evidence. He would slowly give way, however, when figures were brought against him, for then you had him on his own ground. He was always pleased to be of service to any member of the Society, and he took an active and influential part in obtaining the appointment of Government Inspector of Alkali Works for one of our late members.

In the Royal Society's list of scientific papers his name will be found associated with numerous communications; some of these were published in the Monthly Notices of the Royal Astronomical Society, some in the *Astronomische Nachrichten*, but the greater and most important portion of his work was given to our own Society. The earliest paper mentioned in the list, is one on the variability of λ Tauri (*Astronomical Society Monthly Notices*, ix., 1848-49). The list also includes a joint note by J. Baxendell and H. E. Roscoe, on the relative intensities of direct sunlight and diffuse daylight at different altitudes of the sun (*Proceedings of the Royal Society*, vol. xv.); during the latter part of his life he also published some articles in the *Observatory* and *Liverpool Astronomical Society's Journal.*

He was elected a member of this Society in 1858, and a member of the Council, January 25, 1859, in place of the late Rev. H. H. Jones; he was appointed secretary and editor of the Society's publications in 1861; the secretaryship he retained until 1885, when, to the regret of the members, he retired on account of ill-health; for one year he was a vice-president. He was also an active member of the Physical and Mathematical Section, being one of its founders in 1859, the original members being Robert Worthington, J. W. Long, E. W. Binney, Joseph Baxendell, J. B. Dancer, S. W. Williamson, W. L. Dickenson, G. C. Lowe, Joseph Sidebotham, Thomas Carrick, George Mosley, and Thomas Heelis. This list of names reminds us how many have been the changes in the Society since 1859; of all mentioned not one now survives. Most of Mr. Baxendell's papers were in the first instance communicated to this section; the quiet social character of the meetings seemed quite in harmony with his retiring disposition; first there was the half-hour spent in pleasant conversation over tea, and, when the cloth was drawn, the half-dozen members, or thereabout, who ordinarily composed a meeting, would draw up to the green baize table, with the President of the Section at one end, a cheerful fire would give a pleasant glow to the old council room, and four wax candles, if they could not compete with modern methods of illumination, were not without a certain charm, reminding us that we belonged to an old society, and recalling the days of Mainwaring, Massey, Percival, Henry, Dalton, and other old worthies of the Society. To such an audience Mr. Baxendell would read his papers in a low-toned voice but marked with earnestness. Of this section he was elected president ten times. He always spoke in very high terms of the Literary and Philosophical Society, he would even declare that no other Society had done so much useful work, an opinion which might appear extravagant to a stranger unacquainted with its past history; to form some estimate of it, let us reflect that systematic chemistry, which has been such a powerful agent in increasing the resources of civilized life, had its origin here, while the text books of the engineer bear testimony to the useful work of Hodgkinson; if living names were mentioned, they would supply a strong proof of the useful work of the Society, and so lend confirmation to Mr. Baxendell's opinion. This character of use is also stamped on his own work; he took a warm interest in the plan of supplying storm warnings, and made a vigorous protest when the Board of Trade announced an intention of discontinuing them; he was also anxious to obtain definite information of the influence of meteorological conditions on public health. His warning of the dry summer of 1868 was very serviceable to the Manchester Corporation Water Works in regulating the supply of water. On another occasion his warning at Southport, to take precautionary measures against an epidemic, was followed by an outbreak of small-pox. The interest which he took in this Society was also testified by his assiduous attention to the duties of Secretary; his intimate knowledge of the rules made him a very valuable officer of the Society; of the strict observance of these rules he was very tenacious, both with regard to himself and others. He was also opposed to any popular administration of the Society, which under a delusive appearance of prosperity would contribute no real advantage to the purposes for which it was founded. His devotion to astronomy and meteorology gave a decided bias towards these subjects in the work and discussions of the Society; he was also the means of bringing to it the work of other meteorologists, amongst whom may be named the late G. V. Vernon, the Rev. J. C. Bates (of Castleton), Dr. Black, and the Rev. T. Mackereth. His activity in the interests of the Society continued until a few years back, when he was afflicted with a disease in the lower jaw, attended with a series of painful abscesses; in addition he was at times troubled with a difficulty of breathing. On a partial recovery, he attempted to resume his old regularity of attendance, and would even venture out on cold wintry nights to do so; but his appearance made it painfully evident to a spectator that his constitution was thoroughly undermined. His latest residence was at Southport; here he was appointed superintendent of an observatory in Hesketh Park, fitted up and presented by Mr. John Fernley, formerly of Manchester. In his private observatory at Birkdale he resumed his astronomical work, in which he had the valuable assistance of his son, who has had the advantage of his father's training. He was also meteorologist to the Corporation of Southport; he had been since 1859 astronomer to the Corporation of Manchester, succeeding the Rev. H. H. Jones. He was elected a Fellow of the Royal Astronomical Society in 1858, and a Fellow of the Royal Society in 1884. Of foreign societies, he was a corresponding member of the Roy. Phys. Econ. Soc., Königsberg, and Acad. Sci. and Lit., Palermo.

Before proceeding to an account of his work in this

Society, it may be mentioned that in later life he took an intense interest in the history of the Great Pyramid; he seemed to think that the builders of it were under some kind of inspiration, and that in the dimensions of certain passages and chambers were contained the most recent and accurate measurements made in physical astronomy, and also some of those numbers which mark epochs in religious history. Some of his calculations were given in a paper read before the Physical and Mathematical Section, but not published, possibly because he did not think it would be suitable for the Society, perhaps because he wished to subject it to further consideration. On enquiry, I am informed that his interest in this work, and in the fulfilment of prophecy, continued to the last. Some of his results were contributed to the *International Standard*, published by the International Institute for Preserving and Perfecting Weights and Measures, Cleveland, Ohio; some of his calculations in connection with this subject remained unfinished. He closed his mortal life October 7th, 1887, in the 73rd year of his age.

The following opinion of his position as a meteorologist, by one who has laboured in the same field, will form a suitable preface to an account of his work given to this Society. In an article in *Nature*, Dr. Balfour Stewart states:—"Baxendell's contributions to meteorology are very important, and in one branch of the science he may claim to be the pioneer. In 1871, from an analysis of eleven years' observations of the Radcliffe Observatory, Oxford, he came to the conclusion that the forces which produce the movements of the atmosphere are more energetic in years of maximum than in years of minimum sun spot activity. This conclusion has now been confirmed in various directions by other observers. We have heard it objected that Baxendell generalised from a comparatively small number of observations; but in a question like this such a procedure is essential to the pioneer. His task is to deduce, with a mixture of boldness and prudence, something of human interest out of the observations already accumulated, and thus to stimulate meteorologists not only to go on with their labour, but to cover more ground in the future than they have covered in the past. Baxendell's procedure in this respect has been abundantly fortified by the fact that many other men of science are followers in his footsteps."

His first communication was a note on Donati's comet, October 19th, 1858; during this Session (1858-59) he also contributed a note "On Solar Spots." In Session 1859-60, "On the Barometric Pressure on November 10th, 1859"; "Direction of a Storm Indicated by Meteors"; "November Wave of Barometric Pressure"; "Rotation of Jupiter." The appearance of several spots induced him to make a series of observations with a view of obtaining a re-determination of the planets' period of rotation, and to test the conclusion drawn from the observations of Cassini, Sir W. Herschel, Schoeten, &c., to the effect that different spots have different periods of rotation. His own observations confirm the conclusion drawn from earlier observations, that the different spots have different periods of rotation; Cassini's observation that spots near the equator move more rapidly than those more remote is not confirmed; the rotation of the planet cannot with any certainty be deduced from the motion of the spots.—"On a new variable star, R Sagittæ"; "Observations of the Zodiacal Light"; "Remarks on the Theory of Rain." After discussing the views of Professor Phillips, from a consideration of the amount of rainfall at different elevations above the ground, he concludes that only a very small portion of the total augmentation of a rain drop can be due to the condensation of vapour upon its surface, and that by far the greater portion must be due to the disposition of moisture which has already lost its latent heat or heat of elasticity, and which is, therefore, not in the state of a true vapour, although on the other hand the invisibility in the atmosphere under ordinary circumstances, in the form of cloud or fog, renders it difficult to suppose that it can be in the ordinary liquid state. If the vapour brought by a rainy wind retains its latent heat up to the moment that actual precipitation of rain takes place, the sudden disengagement of the heat, although occurring in the higher regions of the atmosphere, ought to have a very sensible effect in raising the mean temperature of rainy days, but no such effect is produced. To account for the enormous quantity of heat given off by the vapour which is condensed in the atmosphere, he thinks that it is probable, that air nearly saturated with vapour has a greater power of radiating heat than dry air. The unusual transparence of the atmosphere often observed immediately before, and even during showers, is probably due to its being charged with vapour which has lost its latent heat. "Observations of the Oblique Belt on Jupiter."

Session 1860-61.—"Phenomena of Solar Spots"; "On a System of Periodic Disturbances of Atmospheric Pressure in Europe and Northern Asia." In an enquiry of this kind he states that determinations of the *statical* element of mean pressure are obviously of very limited use, but notwithstanding the importance of the subject, meteorologists have hitherto generally neglected to ascertain even approximately the value of the *dynamical* element as represented by the extent and frequency of the oscillations of the mercurial column. He gives tables showing the mean monthly and annual sums of the oscillations of the barometer at seven stations in Europe and six in Asia, derived from observations extending over periods varying from six to fifteen years. He remarks that the full application of the method employed appears to have been made by Dr. Dalton in his meteorological essays.—"Note on the Phenomena of Solar Spots." From some data of Dr. Wolf's by the method of least squares, he deduces a mean period of 11·086 years. The mean epoch of minimum frequency being 1732·96.—"Rain near Whitehaven"; "Luminous Fogs"; "On the Irregular Oscillations of the Barometer at Lisbon." From the titles it appears that the maximum amount of oscillation occurs in January and the minimum in July, precisely as in the British Islands, and therefore agreeing with the law of disturbance announced by the author in a former paper.

Session 1861-62.—"Observations of Comet I in 1861"; "Remarkable Solar Spot"; "Rain Following Discharge of Ordnance." In this note he refers to the disputed point whether in a thunderstorm a discharge of lightning is the cause or the consequence of a sudden formation of a shower of rain.—"On the Influence of the Seasons on the rate of decrease of the temperature of the atmosphere with increase of height in different latitudes in Europe and Asia." In this paper he states that from numerous observations made at elevated stations in Europe and India it has been concluded—1st, that the general rate of decrease of the temperature of the atmosphere with increase of height, is least in low, and greatest in high latitudes; and, 2nd, that the rate of decrease is greatest in the summer and least in the winter months. Some of his results, obtained in the course of an investigation of the relations which exist between the falls of rain and changes of barometric pressure, and of the decrement of temperature of the atmosphere in different localities, led him to doubt the general correctness of the second of these conclusions, and he therefore examined all the observations that were accessible to him that seemed likely to throw any light on the subject; he obtained some results which seem to prove the existence of a belt in the temperate latitudes of Europe and Asia, in which the decrease of temperature for a given ascent in the atmosphere is greatest in the winter months, while at stations north or south of the belt, so far as observations have yet been made, the decrease is greatest in the summer months. This belt passes over Portugal, Spain, Sicily, Southern Italy, the Caucasian provinces and Southern Siberia. He also calls attention to some results which seem to indicate that the annual rate of decrease of temperature on ascending in the atmosphere is subject to a periodical change. He remarks that the epoch when the rate of decrease was at a maximum, as shown by the Geneva and Great St. Bernard observations, corresponds exactly with the epoch of minimum magnetic disturbance as determined by General Sabine from observations made at the Colonial Observatories and at Pekin ; and it is probable that there is also a close correspondence between the *periods* of the two phenomena. In conclusion, he thanks Mr. Vernon for his assistance, and adds that without the means of reference afforded by the many valuable volumes of meteorological observations now in the Society's library, it would have been quite impossible to have undertaken an enquiry of this nature.—" Observations of Saturn." He finds that the plane of the ring is not parallel to the dark belts on the body of the planet.—" On the relation between the decrement of temperature on ascending in the atmosphere and other meteorological elements." From a discussion of the monthly results of the observations made during the years 1848-58 at Geneva and on the Great St. Bernard, given by Mr. Vernon in his paper " On the Irregular Barometric Oscillations" at those places, he concludes—1st, That on the average of the year a decrement of temperature below the mean is accompanied by a rainfall and amount of barometric oscillation *below* the mean, and by a mean temperature and barometric pressure *above* the mean. 2nd, A decrement of temperature above the mean is accompanied by a rainfall and amount of barometric oscillation *above* the mean, and by a mean temperature and barometric pressure *below* the mean. 3rd, A decrement of temperature above the mean for the season is due to a cooling of the higher strata of the atmosphere, and not to a heating of the lower strata. 4th, The production of rain is attended with a diminution of the general temperature of the atmosphere, the diminution being greater in the higher than in the lower strata. It also seems probable that one of the essential conditions in the formation of a rotatory or cyclonic storm is a greater difference of temperature than usual between the successive strata of the atmosphere at the point where the storm originates.

Session 1862-63.--"Remarkable Atmospheric Phenomena"; "On a variable star." Notice of a variable star near the nebula, discovered by Mr. Hind in 1852 in the constellation Taurus, but which had now disappeared. "Oscillations of Temperature at Greenwich"; "Iris Diaphragm"; On a new Variable Star T Aquilæ"; "On a Periodic Change in the magnetic condition of the earth and in the Distribution of Temperature on its surface." The irregularities observed in some of the variable stars led him to suppose as highly probable that the light of the sun, and also its magnetic and heating power, might be subjected to changes of a more complicated nature than has been hitherto supposed, and that beside the changes which are indicated by the greater or less frequency of solar spots, other changes of a minor character, and occurring in shorter periods, might also take place. For magnetical observations he selected those made at St. Petersburg, the most northern station at which hourly magnetical observations have been made for any lengthened period. An examination of the magnetic declinations for 1848 indicated changes of activity taking place in a period of 31 days. This period would not apply to the observations of succeeding years, and he was led to think that it might be variable in different years. For 1856 he got a period of 23 days, for 1859 a period of 32 days. These results suggested the idea that the variable period thus found was in some way connected with and dependent upon the great solar spot period, the minimum value occurring in the year of minimum frequency of the solar spots and the maximum values in the years when the spots were most numerous. Several series of thermometrical observations were now examined for indications of periodical changes in the element of mean daily temperature, and it was found that they exhibited with unexpected distinctness changes in the element, occurring also in a variable period, the range of variation, however, being somewhat less than in the case of the magnetic element, although the times of maximum and minimum were almost exactly the same. The maximum and minimum values were respectively 31 and 23½ days. He also refers to another period having a mean duration of rather over eighteen months first observed in discussing the Greenwich magnetical observations for the years 1848 to 1859. In this paper he regards all the movements of the magnet, whether large or small, as having a common origin. General Sabine separates the larger movements from the gross mass and treats them as extraordinary disturbances. With regard to the variability of the short period, he thinks that the facts would perhaps be best explained by supposing (1) that a ring of nebulous matter exists differing in density or constitution in different parts, or several masses of such matter forming a discontinuous ring, and circulating round the sun in a plane nearly coincident with the plane of the ecliptic, and at a mean distance from the sun of about one-sixth of the radius of the earth's orbit; (2) that the attractive force of the sun on the matter of the ring is alternately increased and diminished by the operation of the force which produces the solar spots being greatest at the time of minimum solar spot frequency, and least when the spots are most numerous; (3) the attractive force being variable, the dimensions of the ring and its period of revolution round the sun will also vary, their maximum and minimum values occurring respectively at the time of maximum and minimum solar spot frequency. The matter of the supposed ring may be diamagnetic and, being much nearer to the sun than any of the known planets, of much greater bulk and lightness, and being subjected to a much higher temperature it will be very sensibly affected by the changes which take place in the magnetic condition of the sun, and when interposed between the sun and the earth it may act not only by reflecting and absorbing a portion of the heat and light which would otherwise reach the earth, but also by altering the direction of the lines of magnetic force; we may also fairly conclude that the action of the supposed ring of nebulous matter is principally of a magnetic, and but slightly of a thermal character. From the max. and min. values of the temperature period the greatest and least values of the sidereal period of revolution of the ring will be 29·12, and 22·08 days respectively. From these numbers we find that the greatest distance of the ring from the sun is 0·185, the radius of the earth's orbit being taken as unity, the least distance 0·154, and the mean 0·169. The greatest attractive force of the sun on the ring being taken as unity the least will be 0·619—the difference, he thinks, may be taken as a measure of the force concerned in the production of the solar spots. He then refers to Leverrier's observations on the motion of Mercury, leading to the view that there was a disturbing body circulating round the sun within the planet's orbit, and that the mass consisted of a ring of small bodies; the mean distance which Leverrier regarded as the most probable is precisely that which the author has found for the ring of nebulous matter whose existence he has assumed. "This unexpected and unlooked for agreement, between results arrived at from considerations and by methods so totally different, seems to establish the existence of this ring with quite as much certainty as the results of the profound researches of Adams and Leverrier established the existence of Neptune before that planet had been actually seen ; this ring, however, owing to its proximity to the sun may never be seen, and like the dark companions of Procyon and Sirius it may be only known to us through its action on the other bodies of the system of which it forms a part. Should future researches place its existence beyond doubt, this will, it is believed, be the first instance in which the conclusions of physical astronomy have been confirmed by the results of an investigation of magnetical and meteorological phenomena." "On the Velocity of Light Balls."

Session 1864-65.—"Earthquake of September 25th, 1864"; "Note on a New Variable Star near the Greenwich Variable, No. 1773 of the Twelve Years' Catalogue"; "Note on the Period and Changes of the Greenwich Variable in Vulpecula, No. 1773 of the Twelve Years' Catalogue"; "Observations of an Auroral Arch"; "On the Thermometer Constructed by Dr. Dalton"; "Note on Mr. Bates' Rain Guage and Anemometer Observations."

Session 1865-66.—"Auroral Phenomena, October 9th and 26th, 1865"; "On a Probable Cause of Cattle Disease"; "Note on the Variable Star S Delphini"; "On Meteors"; "Note on the Variable Star T Aquilæ"; "Note on the Cattle Plague"; "Storm Warnings in India"; "Note on the Variable Star S Coronæ"; "On the Determination of the Mean Form of the Light Curve of a Variable Star"; "On the Fall of Rain During the Different Hours of the Day as Deduced from a Series of Observations made by the Rev. J. C. Bates, of St. Martin's Parsonage, Castleton Moor." "On a New Variable Star, R Crateris."

Session 1866-67.—"Observations of the Eclipse of the Sun, October 8th, 1866, at Mr. Worthington's Observatory, Crumpsall"; "Observation of the Meteoric Shower, November 13-14, 1866." His observations were directed principally to the determination of the time of maximum frequency, and the position of the radiant point; he also made an attempt to estimate roughly the relative number of meteors of different magnitudes. In this paper he goes on to say, "As I had the good fortune to witness the great meteoric shower which occurred on the morning of the 13th November, 1833, I may state that the late display was far inferior to it both in the number of meteors seen, and in the brilliancy of the larger ones, and I am therefore inclined to think that a much finer display may be expected to occur in November next. At the time of the 1833 great shower I was at sea off the west coast of Central America, and although then I knew little about meteors, and the idea of a radiant point had not, so far as I am aware, occurred to any astronomer or meteorologist, the tendency of the great majority of the meteors to diverge from a particular region of the heavens was so strongly marked that it at once engaged my attention, and I find, on referring to my notes, that I fixed the central point of this region in the constellation Cancer, a few degrees east of the stars δ and γ, and not in Leo as observed by Professor Olmsted and others in the north-western portion of the North American Continent. A great number of the meteors however had other radiant points, and some of the finest moved in long horizontal arcs, or in a direction nearly perpendicular to that of the main stream."—"Observations of the New Variable Star T Coronæ." This star was remarkable for the great and rapid changes in the intensity of its light. When first observed by Mr. Baxendell on May 15th its intensity was estimated to be 331·2, the intensity of the light of a star of the 10th magnitude being taken as unity; by June 16th it had sunk to 1·7; it is probable that its intensity on May 12th when it was first seen could not be less than 912·1. An inspection of the curve of intensities suggests strongly the idea that a force of an explosive character, such as could result only from the action of highly elastic gaseous matter, had been in operation to produce the sudden increase and subsequent rapid diminution of brightness which had taken place ; but as some of the well-known periodical variables exhibit an equal and even a greater rapidity of change, this view cannot at present be received with much confidence; and notwithstanding the remarkable and highly interesting conclusions which Mr. Huggins and Dr. W. A. Miller have drawn from the results of their spectroscopic observations of this new variable, we are constrained to admit that the cause of variability is still involved in the deepest mystery.—" On the Recent Suspensions by the Board of Trade of Cautionary Storm Warnings,"—a protest against the action of the board in suspending Admiral Fitzroy's system of storm warnings.—" Observations of the Occultation of Aldebaran by the Moon, January 16th, 1867"; "Elements of the Variable Star R Persei"; "On Dr. Buys Ballot's Weather Signal"; " On Storm Warnings,"—a note expressing dissatisfaction with the Board of Trade's proposed substitution for the storm warnings."—" Observation of the Eclipse of the Sun, March 6th, 1867."

Session 1867-68.—" On Solar Radiation." The observations employed in this paper were those made at the Radcliffe Observatory, Oxford, from 1859 to 1864. From these numbers and the curves deduced he draws the following conclusions: 1st—That the calorific intensity of the sun is subject to periodical changes, the maxima and minima of which correspond respectively with those of solar spot frequency. 2nd—That the intensity of a ray of direct sunlight on its arrival at the earth's surface in the latitude of Oxford is greater in April and September than in June, when the sun's meridional altitude is greatest. 3rd—That the curve representing the mean monthly values of solar radiation on cloudless days, has its time of maxima and minima corresponding with those of the curve representing the mean monthly diurnal ranges of the magnetometer. 4th—It seems probable that the heating rays of the sun consist of two kinds differing considerably in intensity, and being subject to periodical changes, the times of maximum of one kind and those of minimum of the other, corresponding respectively to the time of maximum frequency of solar spots. 5th—That the oscillations of mean daily temperature are intimately connected with the changes which take place in the earth's horizontal magnetic intensity. The results derived from the Greenwich observations he states to have been anomalous and unsatisfactory.—"On Solar Radiation, Part II." He applies to his first paper a correction for the difference of meridian altitude of the sun in the different months of the year. He also discusses some of Mr. Mackereth's observations at Eccles in connection with the subject. From his results he derives the following conclusions: 1st—The power of the atmosphere to absorb the heating rays of the sun is much greater in the summer than in the winter months, and depends apparently upon the amount of aqueous vapour which it contains. 2nd—Clouds and haze are less prevalent during the day, or their power to intercept the heating rays of the sun is less active in the spring and autumn than in the winter and summer months. 3rd—Observations of solar radiation made with a black bulb thermometer to be of value ought to be taken with the radiation thermometer placed at the same height above the ground as the shaded maximum thermometer with which it is compared; but while freely exposed at all times to direct sunlight, it ought to be protected as much as possible from disturbing influences. 4th—Solar radiation observations made on a plan similar to that adopted at Oxford, show that the calorific intensity of the sun's light continued to diminish during the years 1865-66, when the frequency of solar spots was also diminishing, thus giving additional weight to the probability that changes in the heating power of the sun's rays are intimately connected with variations in solar spot frequency.—"On the Supposed Influence of the Moon on the Temperature of the Atmosphere." A discussion of a paper contained in the monthly notices of the Royal Astronomical Society, entitled "Inductive proof of the Moon's insolation," by J. Park Harrison, M.A. After an examination of the evidence he comes to the conclusion that Mr. Harrison's results cannot be regarded as a proof of the moon's insolation; or that it has any sensible effect upon the temperature of the atmosphere near the surface of the earth.

Session 1868-69.—"Observations of Atmospheric Ozone." He thinks it probable that the amount of ozone near the earth's surface is dependent upon the height at which clouds are formed in the atmosphere. He gives his opinion with hesitation, and states that the subject is one in which the meteorologist requires the aid of a chemist, and that the method now employed for detecting the presence of ozone in the atmosphere and measuring its amount is very imperfect, and the causes of its frequently sudden development, and almost equally rapid disappearance, are at present involved in mystery. In a subsequent paper the late Professor Jevons states, "During my own observations on ozone I felt strongly the imperfection of the method of measurement alluded to by Mr. Baxendell, and I thoroughly agree with him that the mysterious variation of ozone will not be understood until not only the quantity of air brought into contact with the paper be measured, or regulated, but the varying source and magnitude of supply be considered."—"On the Lunar Spot IVAα17, IVAζ39"; "Observations of the Transit of Mercury"; "The Bleaching Action of the Atmosphere on Ozone Test Papers on the Day of the Colliery Explosion at Hindley Green;" "On a Diurnal

Inequality in the Direction and Velocity of the Wind, apparently connected with the Daily Changes of Magnetic Declination." The observations made use of in this paper are those of the Radcliffe Observatory, Oxford, from 1859 to 1865. He finds that about 7 a.m. a force, which has been almost if not quite inoperative during the previous ten hours, begins to act on the wind from a westerly direction, and gradually but rapidly increasing in intensity, produces its maximum effect between 1 and 2 p.m.; it then gradually diminishes, and finally ceases to act about 9 p.m. The intensity of the force, as measured by the changes which it produces in the direction and velocity of the wind, is at its mean value during its increase at about 9.32 a.m., and during its decrease at about 5.12 p.m. Now these times correspond very nearly with those at which the magnetic declination is at the mean for the day, as determined from the Greenwich magnetic observations. He also finds that the effect of this additional force was to impel the air through a distance of 16·3 miles in a direction almost perpendicular to the magnetic meridian. His results appear to show that the greatest easterly deflection should be taken as the direction of the true magnetic meridian, and that the daily oscillations are due to one disturbing force only, which, when in operation, acts always in the same direction. One may naturally feel surprised, on reading this paper of Mr. Baxendell's, to find that two phenomena so varied in character have a connection; the winds we have long been accustomed to regard as a type of fickleness, while the magnet has furnished a popular emblem of constancy.—"On the Fall of Rain at Different Periods of the Day in connection with the Diurnal Changes of Magnetic Declination." In an earlier paper, on some rainfall observations made by the Rev. J. C. Bates, Mr. Baxendell had pointed out that the curve which represented the daily variations of rainfall had well marked points of imilarity to that of the daily variations of magnetic declination. In a paper read before the Meteorological Society, November 20th, 1867, the President (Mr. Glaisher) states:—"There is a kind of agreement between the curve of frequency and that of the magnetic variation; but in comparing it with that of the amount of rain there is nothing similar in the two curves, and therefore there does not seem to be any connection between the diurnal movements of the declination magnet and the diurnal fall of rain." Mr. Glaisher used the Greenwich observations. Mr. Baxendell maintains that the Greenwich observations, when carefully examined, and discussed, lead to the same general conclusion which he had formerly announced, that a connection exists between the daily variation of the rainfall and the daily movements of the declination magnet.—"On the Aurora of April 15th, 1869."

Session 1869-70.—"On the Influence of Changes in the Character of the Seasons upon the Rate of Mortality." From an examination of the rates of mortality in Lancashire, Cheshire, and the West Riding given in the annual report of the Registrar General, he finds that the average rate was decidedly greater during five years of dry springs and summers, with wet autumns and winters, than during eight years when the seasons were of an opposite character, the mean amount of increase being 9·1 per cent, which in Lancashire alone represents an increase of more than seven thousand in the total number of deaths in one year. The general results of his investigation he briefly recapitulates as follows: 1st—That the influence of meteorological causes is much greater than that of any other recognised influence. 2nd—That the class of diseases which is most affected by meteorological changes is Class I. (zymotic diseases). 3rd—That the relative increase in the number of fatal cases of disease at different ages in unfavourable seasons, is greatest between the ages of 25 and 75 years, or amongst those classes of the community which are most exposed to the vicissitudes of weather. 4th—That the sanitary measures which have been carried out during the last fifteen or twenty years by Boards of Health, Health Committees, and Officers of Health have produced no perceptible improvement in the state of the public health, nor checked the growing increase in the rate of mortality, notwithstanding the enormous outlay they have involved; and that, therefore, a thorough reform of our existing sanitary system is urgently required.—"On Infant Mortality in Manchester": a comparison of the infant mortality in this city with that of several large towns as given in the Registrar General's returns. In this paper he states, "it is therefore clear from these returns that the stigma of carelessness with regard to their children, cast upon the mothers of the working class of Manchester, is most undeserved, and that, in fact, infants and young children are better cared for and attended to in Manchester than in any of the leading manufacturing towns in England." "On the Mortality Returns for Scotland for the last ten years."

Session 1870-71.—"Observations of the Aurora of Oct. 25th, 1870"; "Observation of the Eclipse of the Sun, December, 1870"; "Remarks on Mr. Spence's Experiments on the Effects of Cold on the Strength of Cast Iron." About this time an interesting discussion took place in the Society on the effect of cold on cast iron, in which Dr. Joule, Mr. Brockbank, Dr. Hopkinson, and others took part. From some experiments, Mr. Spence concluded that a specimen of cast iron, having at 70° Fahr. a given power of resistance to transverse strain, will, on its temperature being reduced to zero, have that power increased by 3 per cent. Treating the numerical results of the experiments in accordance with the theory of errors, Mr. Baxendell comes to the conclusion that the experiments, though made with great care, offer no certain evidence that any sensible change takes place in the strength of cast iron when its temperature is reduced from

70° to zero Fahr.—"On a diurnal inequality in the direction and velocity of the wind apparently connected with the daily changes of Magnetic declination." Having combined the results of the anemograph observations made at Oxford during 1867-68 with those of the previous eight years, he finds a confirmation of the opinion expressed in a former paper, relative to a connection of wind movement and daily change of magnetic declination. He also examines whether the mean direction of the wind at Oxford in different years had any relation to the number of spots observed on the sun's disc. Taking the period from 1859 to 1868, it appears that the greatest angle of direction occurred in 1860, which was a year of maximum solar spot frequency, and the least in 1866, when solar spots were least numerous.

Session 1871-72.—"Note on the Destruction of St. Mary's Church, Crumpsall, on the 4th January, 1872, by fire from a lightning discharge"; "On the Changes in the Distribution of Barometric Pressure, Temperature, and Rainfall during a Solar Spot Period." Dividing a period of 11 years, from 1858 to 1868 inclusive, into two periods of maximum and minimum solar frequency, he finds the mean pressure under different winds, and the differences; the differences under north-east, east, south-east, south-west, and west are too considerable to be fairly attributable to accidental causes. A comparison was then made of the mean pressure under north-east, east, and south-east winds with those under south-west and west winds; a maximum difference occurred in 1860 when solar spot frequency was at a maximum, and a minimum difference in 1867 when solar spot frequency was also at a minimum, and the general course of the differences has a remarkable similarity to that of the numbers representing the variations of solar spot frequency. From a comparison of temperature with different winds he finds that in the first period (1858-62) the maximum temperature occurs under winds from south-west, and in the second period (1862-68) under winds from about south south-east. Comparing the mean temperature under south-west winds with that under south and south-east winds, from the differences he finds a maximum in 1860 and a minimum in 1867; it is therefore evident that the distribution of temperature under different winds like that of barometric pressure, is very sensibly influenced by changes which take place in solar activity. He makes a comparison of rainfall during the two periods, 1858-62 and 1862-68, under different winds; he finds that the amounts of rainfall under south-west and west winds are invariably greater than those under south-east and south winds during the years when the number of solar spots was above the average, and invariably less in the years when the number of solar spots was below the average, and further, that the greatest difference in the first series of years occurred in 1860, at the time of a solar spot maximum, and that in the second series, in 1866, at or very near to the time of a solar spot minimum.—"On Distribution of Rainfall under different winds at St. Petersburg during a solar spot period." He states that the hypothesis which led to this investigation requires that great diversity should exist in the relative amounts of rainfall under different winds at different stations, but whatever may be the nature of the distribution at any station, the changes to which it will be subject will take place in a period identical with the solar spot period. After examining the tables of rainfall at St. Petersburg during the eleven years, 1854-64, he finds that the close agreement which exists at St. Petersburg between the maximum and minimum period of solar spots, and those of variation in the distribution of rainfall under different winds, gives increased value to the results derived from the Oxford observations, and affords additional support to the hypothesis which he had advanced in a former paper, that changes in solar activity, and consequently in the magnetic condition of the earth, produced corresponding changes in the direction and velocities of the great currents of the atmosphere, and in the distribution of barometric pressure, temperature, and rainfall.—"Notes on the Relative Velocities of different Winds at Southport and Eccles, near Manchester."

Session 1872-73.—He made no communication to the Society.

Session 1873-74.—No communication.

Session 1875-76.—"On a Source of atmospheric Ozone." In this paper he presents himself to our notice in a new phase not only as an observer, but as an experimenter. He had remarked that when fog or haze were prevalent it rarely happened that even the faintest trace of ozone could be obtained, and came to the conclusion that atmospheric ozone was absorbed or decomposed by haze or fog, and was given off or produced when evaporation changed haze or fog into visible vapour. He had also noticed that haze does not only prevent the coloration of the test papers, but it also rapidly bleaches those which already had been coloured by the action of ozone. The bleaching effect is not produced if the papers are thoroughly wetted by immersion in water, and it has been attributed to another form of oxygen named antozene. The analogy of the constitution of visible vapour and spray from a breaking wave or a fountain led him to make some experiments in the vicinity of the fine fountains at the Arnfield and Hollingworth reservoirs in the Manchester Corporation Waterworks district. At each locality boxes containing ozone papers were placed on the windward and on the leeward side of the fountains. The experiments at both localities showed a marked excess of ozone on the leeward side. The experiments, he thinks, 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. He advances the hypothesis 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. To meet the objection 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 already ozonised, he ventures to offer as an explanation, that ozone associated with moisture and in the presence of the oxidised potassiums, will combine with the freed iodine and form iodic acid, which, uniting with the potash, will form the colourless iodate of potash; or it may 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. That ozone should oxidise the free iodine as Mr. Baxendell suggests to iodic acid seems improbable. The following explanation seems possible: if ozone decompose iodide of potassium into iodine and free alkali, should the paper become slightly damp, the reverse action would take place, and the iodine would be converted into iodide and iodate of potassium. A member of this Society, to whom Mr. Baxendell had often mentioned the bleaching of the papers, stated that he thought he could distinguish those which had been bleached from those which had not been exposed. As a challenge Mr. Baxendell sent four numbered papers which were quite similar in appearance, but revealed a difference when tested; two were stated to have been exposed, and two to be fresh papers. Mr. Baxendell wrote in reply that they were rightly grouped. The method of discrimination was extremely simple, and was communicated to him in the hope that it might be of service in his future work on ozone; on dipping the papers into dilute hydrochloric acid, those which had been ozonised and bleached re-assumed a violet tint; those which had not been exposed were initially unaffected.—"On the connection of the Humidity of the Air and the amount of Ozone."

Session 1876-77.—"On the Protection of Buildings from Lightning"; remarks on Professor Maxwell's paper on the subject, read at the recent meeting of the British Association. —"On Changes in the Rates of Mortality from Different Diseases during the Twenty Years 1854-73,"—a discussion of the Registrar General's mortality returns during the period, which he divides into two equal parts, comparing the death rates of eight of the principal infectious diseases; the results show that the mortality from seven has diminished very sensibly, while that from small-pox shows an extraordinary increase, the percentage of increase of death rate being 86·3; he also found that the adult portion of the population were much more susceptible to its attacks. A comparison of diseases of the non-preventible class during the two periods showed for some an increase, and for others a decrease. He also gives an analysis of the death returns of a few of the more important diseases in the lists. From his results he concludes that sanitary measures, tested by their effect on the diseases which are universally admitted to be infectious, have produced a slight improvement in the public health which is equivalent to the saving of one life in every 134, or a reduction of 0·17 in the general death rate; but tested by their effect on the whole class of zymotic diseases they have caused no improvement whatever, and have not even prevented an increase in the mortality from these diseases, which is equivalent to an extra loss of life in every 417. From the returns with regard to small-pox, he states that the experience of the last and of the present epidemic has furnished abundant proof that vaccination does not, as it did in Jenner's time and for many years after, afford an almost certain protection against its attacks. He also states that the reduction in the rate of mortality from the class of infectious or preventible diseases, has been more than counterbalanced by an increase in the rate from the non-preventible class. This paper of Mr. Baxendell's did not pass without criticism. Another of our members, Dr. Arthur Ransome, replied to it in a paper printed in the sixth volume of the Memoirs (third series) entitled "Losses and Gains in the Death-toll of England and Wales during the last Thirty Years." Speaking of the source from which Mr. Baxendell drew the materials for his deductions, he states that unfortunately the returns of the Registrar General cannot be relied on for the species of information which he seeks to obtain from them; the drawbacks to the utility of the returns had often been pointed out, and in the early reports of the Registrar General, Dr. Farr himself complained of the imperfect nomenclature of disease. In reference to Mr. Baxendell's remarks on the great increase of small-pox, Dr. Ransome states, "his remarks on this point are undoubtedly very important, and will need to be well weighed by those who are responsible for the effective performance of vaccination. It points to some imperfection in the operation, or to a possible deterioration in the quality of the lymph owing to its transmission too constantly through the human subject; in any case its cause is worthy of full and patient investigation." With reference to sanitary improvements he states, "it will be seen that I entirely agree with Mr. Baxendell in thinking that the present sanitary system is very defective, but it by no means follows that it has done no good." Mr. Baxendell continued his investigations on the action of vaccination. His next paper was "On the Increased Mortality from Small-Pox." In this paper he continues his argument against vaccination as a preventive of small-pox. As a test of its value he has taken the small-pox statistics of London—the best vaccinated town in the country—and compared the results of the five years 1849-52, before vaccination was made compulsory, with those of the five years 1869-73, when compulsory vaccination had been twenty years in operation; the results confirm him in his previous opinion that vaccination had ceased to be a remedy. He states, "so far from vaccination having been the means of saving many thousand lives annually, as has often been very rashly stated, the stern facts recorded in the annual reports of the Registrar General prove beyond all question that, in the best vaccinated city in the kingdom, the death rate among the vaccinated alone is now equal to that which prevailed among the unvaccinated before compulsory vaccination laws were passed; that the number of cases from small-pox has nearly doubled, and that the number of deaths of adults has also greatly increased."

Session 1877-78.—"Transit of the Shadow of Titan across the Disc of Saturn, November 23rd, 1877."

Session 1878-79.—"Observations of Dr. Klein's new Lunar Crater near Hyginus, made at the Observatory, Birkdale"; "On the Meteorological Effects of the position of the Moon with respect to the Sun." From observations made at Southport, he concludes that at Southport, during the winter months, the mean daily range of temperature is on the average greater on the days of full moon than on the days of new moon. From cloud observations, he finds that at 9 a.m., the mean amount of cloud is slightly greater on days of new moon than on days of full moon; at 1 p.m. the amounts are nearly equal; but at 9 p.m. the amount on days of full moon is greater than on days of new moon. It has been supposed by some meteorologists that the full moon had the effect of partially dispersing the clouds, but his own results show very clearly that any effect which the moon may have is of an opposite character, as in every winter the mean amount of cloud was greater at the time of full moon than of new moon. The observations of mean daily temperature show that the days of full moon were on the average 1·19° colder than the days of new moon. He was led to infer that at times of full moon, northerly winds had been more frequent than at the times of new moon; the observations made at Southport confirmed this view. The numbers obtained also indicated that the frequency of northerly winds under the full moon and last quarter, as compared with that under the new moon and first quarter, has gradually diminished during the seven years (1871-78) of observation. Assuming that the diminution is due to the gradual diminution of solar activity, the ratio might be expected to be a minimum during the year 1878-79. An examination of the Radcliffe observations confirmed his opinion that the moon exercises a noticeable influence on the direction of the wind.

Session 1879-1880.—"Results of Observations of the Double Period Variable Star R Sagittæ"; "Note on three New Stars"; "Results of Observations of the Variable Star T Aquilæ."

Session 1880-81.—"Ozone and the Rate of Mortality of Southport during the nine years 1872-1880." From observations made during the period, he found that in four of the five years of low amounts of ozone the zymotic death rate was above the mean, and in the fifth slightly below; and in the four years of high amounts, the rate was always below the average. During the five years of low amounts of ozone the gross death rate was 12·8 per cent greater than in the four years of high amounts of ozone, the local death rate 10·9 per cent, and the zymotic death rate 92·6 per cent greater. He thinks that the corrected amounts of ozone represent the actual purity of the air at Southport during the nine years, and that variations in the actual amount exercise a very sensible influence upon the state of public health.

Session 1881-82.—" Note on the Variable Stars U Canis minoris, V Geminorum, and U Bootis."

During the next two sessions he made no communications.

Session 1884-85.—" Notes on the visibility of the Moon during total Lunar Eclipses." His last paper was " On the Reversion of the Minima of the double period Variable Star R Sagittæ," read November 18th, 1884.

Mr. Baxendell sought no applause while living; to refrain from adding it now will be to respect a wish, casually expressed about three years ago, that when his time came he should like to slip out of the world as quietly as possible. The approval of his work, by those who are capable of judging of its merits, will supply a testimony to its worth of greater value than any studied eulogy with which the writer of this memoir could conclude his task.

Ordinary Meeting, December 27th, 1887.

Mr. W. H. JOHNSON in the Chair.

Reference was made to the untimely loss sustained by the Society in the sudden death of its President, the late Prof. Balfour Stewart. It was thought more suitable to postpone passing a vote of condolence to the late President's family in consequence of the attendance being very small.

Mr. JAMES SMITH communicated the following note on the bi-centenary of the *Principia* :—

This year being the bi-centenary of the publication of Newton's *Principia*, I think the fact should be noted in our *Memoirs*, as it ought not to be allowed to pass over without attention being directed to it. The second edition of the *Principia* was published in 1713, and is known as "Cotes' Edition," he having assisted Newton in the revision of the work, and written a preface to it. Newton had a very high opinion of his mathematical abilities. The third edition, and the last published during the life-time of the great author, is dated 1726, and is known as "Pemberton's Edition," he having had charge of revising it under the direction of Newton. It was the intention of Dr. Pemberton to have published an English translation of the *Principia*, with a comment, but the publication of Motte's translation in 1729, prevented him from proceeding with his design. Very little appears to be known about Andrew Motte, whose name is thus associated with the *Principia*, and who deserves much praise for his labours in connection with it.

Ordinary Meeting, January 10th, 1888.

Professor W. C. WILLIAMSON, LL.D., F.R.S., Vice-President, in the Chair.

The Chairman referred to the sudden death of the President of the Society, Professor Balfour Stewart, LL.D., F.R.S., and it was moved by Dr. Burghardt, seconded by Mr. Francis Jones, and resolved,—

"That the members of the Manchester Literary and Philosophical Society desire respectfully to offer their sincere sympathy and condolence to Mrs. Stewart and her family in the sad bereavement they have sustained in the loss of Dr. Stewart, the esteemed and distinguished President of the Society; and that the Secretaries be requested to communicate the resolution to Mrs. Stewart."

The Chairman stated that a similar resolution had been adopted by the Council of the Society, and that the Council had requested Dr. Schuster to prepare a memoir on the life and work of Dr. Stewart, to be read before the Society.

Mr. FARADAY communicated the substance of a letter from Mr. George J. Romanes, M.A., LL.D., F.R.S., with reference to experiments bearing on the theory of physiological selection. The letter suggested that "splitting" botanists should look out for *constant* varieties, sow the seeds together with some standard plants for subsequent comparison with the progeny, and then either send all the material to the writer (with diagnostic descriptions of the points of difference), or, if they preferred to conduct the experiments on hybridisation for themselves, should communicate with Mr. Romanes as to the method.

Professor WILLIAMSON announced that the gigantic fossil stigmarian roots of a lepidodendroid or sigillarian tree, discovered some time since, had been erected in the Museum of the Owens College, forming the noblest example of fossilised vegetable life yet discovered.

An application of Huyghens' Principle to a spherical wave of light. By R. F. Gwyther, M.A.

This is an attempt to form a theory of diffraction on geometrical principles only. To make such an attempt does not appear to me unreasonable, since, with our present knowledge, one might prefer to look upon the breaking up of a wave as a geometrical artifice rather than as a geometrical representation of some physical phenomena.

Introduction.

We can easily express in terms of co-ordinates the displacements resolved along axes in a hypothetical spherical wave, and for our purposes we need not at first consider any difficulty there may be in understanding how such a wave could originate; our equations will express the nature of its progress when once originated.

As we consider light to consist of displacements, and to be propagated by strains in an ether in which the velocity of normal vibrations is incomparably greater than that of transverse vibrations, and as the principle of the independent co-existence of small motions is essential to the whole theory of light, it is no further hypothesis to assume that at any moment we may regard each element of a disturbed spherical surface to be itself an origin of an elemental wave, the resultant of all such elemental waves reproducing for future time the actual wave motion which we were originally considering. It is my object to determine the form of the displacement in the secondary waves, in order that the resultant displacements may be everywhere equivalent to those of the original wave.

In the first place, I show that if an elemental wave is to represent a plane polarised ray of which the displacement is directed along the axis of y, in order that it may satisfy the condition of admitting of resolution, the displacements must take the form

$$\xi = f_1(x.r)y$$
$$\eta = \phi_2(x.r) + \phi_6(x.r)z^2$$
$$\zeta = -\phi_6(x.r)yz.$$

Making use of a form of solution of the equations of light given by the author in a previous paper quoted, I show that we may write these

$$\xi = -\Sigma\frac{a_n x^{n-1}y}{r^{n+1}}\sin\frac{2\pi}{\lambda}(bt-r) + \text{etc.}$$

$$\eta = \Sigma\frac{a_n x^n + b_n x^{n-2}z^2}{r^{n+1}}\sin\frac{2\pi}{\lambda}(bt-r) + \text{etc.}$$

$$\zeta = -\Sigma\frac{b_n x^{n-2}yz}{r^{n+1}}\sin\frac{2\pi}{\lambda}(bt-r) + \text{etc.}$$

where a_n and b_n are any constants.

Without proceeding further we may notice that this agrees in form with the solution found on dynamical grounds by Professor Stokes. We shall obtain his solution if we put $n=2$ or 3, $a_2=a_3=b_2=b_3=\frac{1}{2\lambda}$, and accelerate the phase by $\frac{\lambda}{4}$. Before going further it may be well to explain that the difficulty I find about this form of displacement consists in this fact and its consequences.

If we consider a point immediately in front of the point of origin of the secondary wave for which $y=0$, $z=0$, $x=r$ we should have

$$\eta = \frac{2a_2}{r}\sin\frac{2\pi}{\lambda}(bt-r),$$

and if we consider the point for which $x=0, y=0, z=r$, we should have

$$\eta = \frac{a_2}{r}\sin\frac{2\pi}{\lambda}(bt-r),$$

giving a displacement one-half of that immediately in front of the aperture. And if, instead of considering an element of surface only, we integrate over a finite portion we get a corresponding result. Hence it would seem probable either that n is greater than 2 or that $b_2=0$.

Returning to the consideration of the problem, imagining disturbances of the form which I have found to originate from every portion of the spherical surface, and finding their resultant at some point, there appear in the expressions, (1) terms depending upon λ/c where c is the radius of the original sphere, which terms can not be made to disappear, and which express the expected fact that we can only apply the principle to a wave of which the radius is large compared with the wave length, and (2) terms depending upon λ/r where r is the distance of the point considered from the surface of the sphere, which all disappear upon integration by a continual appearance of a set of similar series. As these terms disappear we obtain from this investigation no criterion of the value of n or of b, but the fact of their disappearance gives a strong confirmation (which appears in other ways in the paper) of the appropriate nature of the solution of the differential equation used, and of the possibility of satisfying the conditions without taking into consideration any wave of condensation. The only conditions which we thus obtain are

$$\Sigma(-1)^n a_n = 0.$$

$$\Sigma a_n = \frac{1}{\lambda}.$$

In the last part of the paper I consider the case of a wave converging to the origin.

The wave being the secondary wave representing a plane polarised wave, reversed by the reversal of the velocity, I show that the resultant displacement and rotation at the origin will be of the same nature as the original displacement at the origin, if n have the values 2 and 3, and $b_2=0$.

$$a_2 = a_3 = b_3 = \frac{1}{2\lambda}.$$

I thus get as the final form of displacement in the secondary wave

$$\xi = -\left\{\frac{xy}{r^3} + \frac{x^2y}{r^4}\right\}\sin\frac{2\pi}{\lambda}(bt - r)/2\lambda.$$

$$\eta = \left\{\frac{x^2}{r^3} + \frac{x^3 + xz^2}{r^4}\right\}\sin\frac{2\pi}{\lambda}(bt - r)/2\lambda.$$

$$\zeta = -\frac{xyz}{r^4}\sin\frac{2\pi}{\lambda}(bt - r)/2\lambda.$$

§ I.

The object of this paper is to study to what extent an expression can be found to represent, on the basis of Huyghens' principle, the action of a plane polarised ray of light. From simple principles we may learn something of the way in which the co-ordinates must enter such an expression so that they may allow of resolution.

Imagine a ray of plane polarised light to travel along the axis of x and let its components be $a\cos a$ and $a\sin a$ along the axes of y and z, and let, if possible, the consequent disturbance at a point $x.y.z$ be represented by a disturbance in the secondary wave, such that the part of it arising from the component $a\cos a$ along the axis of y may be

$$U = a\cos a(f_1 + f_2y + f_3z + f_4y^2 + f_5yz + f_6z^2 + \&c.)$$
$$V = a\cos a(\phi_1 + \phi_2y + \phi_3z + \phi_4y^2 + \phi_5yz + \phi_6z^2 + \&c.)$$
$$W = a\cos a(\psi_1 + \psi_2y + \psi_3z + \psi_4y^2 + \psi_5yz + \psi_6z^2 + \&c.)$$

when all the functions contain x and r only ($y^2 + z^2$ being always written $r^2 - x^2$ whenever it appears) and the series being continued in the same way.

Hence the part which arises from $a\sin a$ along the axis of z will be represented by

$$U' = \quad a\sin a(f_1 + f_2z - f_3y + f_4z^2 - f_5yz + f_6y^2 + \&c.)$$
$$V' = -a\sin a(\psi_1 + \psi_2z - \psi_3y + \psi_4z^2 - \psi_5yz + \psi_6y^2 + \&c.)$$
$$W' = \quad a\sin a(\phi_1 + \phi_2z - \phi_3y + \phi_4z^2 - \phi_5yz + \phi_6y^2 + \&c.)$$

$U + U'$, $V + V'$, $W + W'$, being the components of the whole disturbance.

Now turn the axes and the plane of yz until the new axis of y is in the direction of the original displacement, then, referred to the new axes, the components of the disturbance are

$$U + U' = a(f_1 + f_2 Y + f_3 Z + f_4 Y^2 + f_5 YZ + f_6 Z^2 + \&c.)$$
$$(V + V')\cos a (W + W')\sin a$$
$$= a(\phi_1 + \phi_2 Y + \phi_3 Z + \phi_4 Y^2 + \phi_5 YZ + \phi_6 Z^2 + \&c.)$$
$$(W + W')\cos a - (V + V')\sin a$$
$$= a(\psi_1 + \psi_2 Y + \psi_3 Z + \psi_4 Y^2 + \psi_5 YZ + \psi_6 Z^2 + \&c.)$$

where

$$Y = y\cos a + z\sin a$$
$$Z = z\cos a - y\sin a.$$

Hence, as we include all the powers of $y^2 + z^2$ and $Y^2 + Z^2$ in the functional part, we may conclude that

$$f_1 = f_4 = f_5 = f_6 = \&c. = 0.$$
$$\phi_2 = \phi_3 = \phi_4 = \&c. = 0. \qquad \psi_5 + \phi_6 = 0.$$
$$\psi_2 = \psi_3 = \psi_6 = \&c. = 0. \qquad \psi_4 + \phi_5 = 0.$$

And therefore that the displacement will take the simpler form

$$\left.\begin{aligned} U &= a\cos a\{f_2 y + f_3 z\} \\ V &= a\cos a\{\phi_1 - \psi_4 yz + \phi_6 z^2\} \\ W &= a\cos a\{\psi_1 + \psi_4 y^2 - \phi_6 yz\} \end{aligned}\right\}\ldots\ldots(1)$$

But this gives merely the form of disturbance suitable for resolution, and does not distinguish the forms for representing suitably the disturbance along the different axes. We may consider it obvious that $\psi_1 = 0$ when the displacement is along the axis of y, the others will be considered later, when we shall show that $f_3 = 0$ $\psi_4 = 0$.

§ 2.

I shall make use of the solution of the equations of the vibration of light given by me in a paper bearing that title (*Proceedings of Camb. Phil. Society*, vol. 5, page 279), and the suitableness of this solution will receive strong support in the course of the paper, from considerations arising from other circumstances than those detailed in that paper.

The solution is in this form. If $(\xi.\eta.\zeta)$ are the components of the displacement in a light wave from a point source

$$\xi = {}_{\xi}\left\{u_{-1} + \frac{u_{-2}}{2p} + \frac{u_{-3}}{2\,!\,2^2p^2} + \frac{u_{-4}}{3\,!\,2^3p^3} + \&c.\right\}\sin p(bt-r)$$
$$+ {}_{\xi}\left\{v_{-1} + \frac{v_{-2}}{2p} + \frac{v_{-3}}{2\,!\,2^2p^2} - \frac{v_{-4}}{3\,!\,2^3p^3} + \&c.\right\}\cos p(bt-r)$$

where p stands for $2\pi/\lambda$, and u_{-1} and v_{-1} any two homogeneous functions whatever of degree -1, from which the terms of other degrees are derived by the laws.

$$\left.\begin{array}{lll} v_{-2} - r\nabla^2 u_{-1} = 0, & v_{-3} - r\nabla^2 u_{-2} = 0, & \&c. \\ u_{-2} + r\nabla^2 v_{-1} = 0, & u_{-3} + r\nabla^2 v_{-2} = 0, & \&c. \end{array}\right\}$$

and the condition $\frac{d\xi}{dx} + \frac{d\eta}{dy} + \frac{d\zeta}{dz} = 0$, will be satisfied provided

$$\left.\begin{array}{l} x_{\xi}u_{-1} + y_{\eta}u_{-1} + z_{\zeta}u_{-1} = 0. \\ x_{\xi}v_{-1} + y_{\eta}v_{-1} + z_{\zeta}v_{-1} = 0. \end{array}\right\}$$

These expressions are to be used in this paper in their full form without approximation, and I shall first show the forms which the terms of other orders will take when

$$u_{-1} = \frac{u_n}{r^{n+1}}$$

where u_n is homogeneous of the n^{th} order in $x.y.z$.

By continually using the formula

$$r\nabla^2\frac{u_n}{r^m} = \frac{\nabla^2 u_n}{r^{m-1}} - \frac{m(2n+1-m)u^n}{r^{m+1}}$$

we get

$$v_{-2} = \frac{\nabla^2 u_n}{r^n} - \frac{n(n+1)u_n}{r^{n+2}}$$

$$u_{-3} = -\frac{\nabla^4 u_n}{r^{n-1}} + 2\frac{(n-1)n\nabla^2 u_n}{r^{n+1}} - \frac{(n-1)n(n+1)(n+2)u_n}{r^{n+3}}$$

$$v_{-4} = -\frac{\nabla^6 u_n}{r^{n-2}} + 3\frac{(n-2)(n-1)\nabla^4 u_n}{r^n} - 3\frac{(n-2)(n-1)n(n+1)\nabla^2 u_n}{r^{n+2}}$$
$$+ \frac{(n-2)\ldots(n+3)u_n}{r^{n+3}}$$

The general term in the expansion being of the form

$$\frac{\nabla^{2q}u_n}{r^{n-q+1}} - q\frac{(n-q+1)(n-q+2)\nabla^{2q-1}u_n}{r^{n-q+3}} + \text{etc.}$$
$$+ (\pm)^q\frac{(n-q+1)\ldots..(n+q)u_n}{r^{n+q+1}}$$

from which it appears that the last term of the expansion will be that for which $q=n$.

As an example we may take a case of vibration along the parallels of a system of spheres referred to a pole on the axis of x.

$$\xi = 0$$

$$\eta = \frac{z}{r^2}\sin p(bt-r) - \frac{z}{pr^3}\cos p(bt-r)$$

$$\zeta = -\frac{y}{r^2}\sin p(bt-r) + \frac{y}{pr^3}\cos p(bt-r)$$

in which the vibrations are accurately on the spheres. And if we perform the expansion for a case of vibrations which are to a first approximation along the corresponding meridians, we get

$$\xi = \left\{\frac{r^2-x^2}{r^3} - \frac{r^2-3x^2}{p^2r^5}\right\}\sin p(bt-r) - \frac{r^2-3x^2}{pr^4}\cos p(bt-r)$$

$$\eta = -\left\{\frac{xy}{r^3} - \frac{3xy}{p^2r^5}\right\}\sin p(bt-r) + \frac{3xy}{pr^4}\cos p(bt-r)$$

$$\zeta = -\left(\frac{xz}{r^3} - \frac{3xz}{p^2r^5}\right)\sin p(bt-r) + \frac{3xz}{pr^4}\cos p(bt-r)$$

In accordance with this solution and the previously considered form for the displacement in a secondary wave, representing, on Huyghens' principle, an elementary portion of a plane polarised wave, we must have in the assumed form of such a secondary disturbance.

$$\left.\begin{aligned} \xi u_{-1} &= \Sigma\frac{c_nx^{n-1}y + d_nx^{n-1}z}{r^{n+1}} \\ \eta u_{-1} &= \Sigma\frac{a_nx^n - e_nx^{n-2}yz + b_nx^{n-2}z^2}{r^{n+1}} \\ \zeta u_{-1} &= \Sigma\frac{e_nx^{n-2}y^2 - b_nx^{n-2}yz}{r^{n+1}} \end{aligned}\right\}\ldots\ldots(2)$$

We have now, if possible, to find the values and relations between the constants in this expression, and to limit the values of n.

Note.—It is impossible to treat the diffraction question without reference to Professor Stokes' work on the subject, and to show the relation to the nature of his solution and the differences from it, I will compare equation (39) page 27 of his reprinted papers (with his notation).

$$\xi = \frac{lk}{4\pi Da^2 r} f\left(t - \frac{r}{a}\right) + \frac{l' - lk}{4\pi Db^2 r} f\left(t - \frac{r}{b}\right) + \frac{3lk - l'}{4\pi Dr^3} \int_{\frac{r}{a}}^{\frac{r}{b}} t' f(t - t') dt'$$

each term of which he explains on page 279.

Write $f(t) = c\sin 2\pi bt/\lambda$, replace $l.m.n$ by $x/r.y/r.z/r$, complete the integration and separate into two parts, we then get

$$\xi = c\left\{\left(\frac{l'}{r} - \frac{x(l'x + m'y + n'z)}{r^3}\right)\sin\frac{2\pi}{\lambda}(bt - r)\right.$$

$$+ \left(\frac{3x(l'x + m'y + n'z)}{r^5} - \frac{l'}{r^3}\right)$$

$$\left.\times\left[\frac{\lambda r}{2\pi}\cos\frac{2\pi}{\lambda}(bt - r) + \left(\frac{\lambda}{2\pi}\right)^2 \sin\frac{2\pi}{\lambda}(bt - r)\right]\right\}\Big/ 4\pi Db^2$$

$$+ c\left\{\frac{x(l'x + m'y + n'z)}{r^3}\sin\frac{2\pi b}{a\lambda}(at - r)\right.$$

$$- \left(\frac{3x(l'x + m'y + n'z)}{r^5} - \frac{l'}{r^3}\right)$$

$$\left.\times\left[\left(\frac{\lambda ra}{2\pi b}\cos\frac{2\pi b}{a\lambda}(at - r) + \left(\frac{\lambda a}{2\pi b}\right)^2 \sin\frac{2\pi b}{a\lambda}(at - r)\right]\right\}\Big/ 4\pi Da^2$$

the wave length in the two waves being in the ratio b/a. Each of these expansions separately is of the form that I have used, the first being without condensation, the second without rotation.

If we now make $a = \infty$, the second expansion gives a single term only, representing a wave of infinite wave length, which would be sensible only near the point of origin of the wave, *viz* :—

$$\left\{\frac{l'}{r^3} - \frac{3x(l'x + m'y + n'z)}{r^5}\right\}\left(\frac{\lambda}{2\pi}\right)^2 \sin\frac{2\pi bt}{\lambda}\Big/ 4\pi Db^2.$$

or $$\frac{d}{dx}\left\{\frac{l'x + m'y + n'z}{r^3}\right\}\left(\frac{\lambda}{2\pi}\right)^2 \sin\frac{2\pi bt}{\lambda}\Big/ 4\pi Db^2.$$

and as far as this term is concerned

$$\frac{d\xi}{dx}+\frac{d\eta}{dy}+\frac{d\zeta}{dz}=0.$$

$$\nabla^2\xi=0.$$

$$\frac{d^2\xi}{at^2}=-\left(\frac{2\pi b}{\lambda}\right)^2\xi.$$

and $a^2\frac{d\delta}{dx}$ must be written $\frac{ap}{dx}$ as explained in Article 9 of Professor Stokes' paper.

If we had considered the full form of the equation on the elastic solid principle, we should have been led to add to $\xi.\eta.\zeta$ terms $\frac{a\phi}{ax}$, $\frac{a\phi}{ay}$, $\frac{d\phi}{dz}$ where ϕ has the form

$$\frac{a}{r}\sin\frac{2\pi bt}{\lambda}+\frac{l'x+m'y+n'z}{r^3}\sin\frac{2\pi bt}{\lambda}$$

$$+\left\{\frac{(p+q+r)}{r^3}-\frac{3(px^2+qy^2+rz^2+hyz+jzx+kxy)}{r^5}\right\}\sin\frac{2\pi bt}{\lambda}+\text{etc.}$$

(or rather such part of it as has the form $yf(x,r)$, the terms being final terms in the form of expansion, which I have used throughout.

§ 3.

I have as yet spoken of a plane polarised wave of light, but obviously any expression which can, on Huyghens' principle, represent a secondary wave corresponding to an element of a plane wave, can equally well represent the secondary wave corresponding to an element of any wave front whatever, provided only the radii of curvature at the element considered are large compared with the wave length. I shall accordingly attempt to find the conditions that we must have in order that a disturbance in a spherical wave of radius c (where λ/c is an infinitesimal quantity), may be reconstructed by the integral disturbances of certain secondary waves arising from all points upon its surface.

Consider, first, the disturbance generally, represented by

$$\zeta = 0$$

$$\eta = \left\{ \frac{x^m z}{r^{m+2}} - \left(\frac{m(m-1)(m-2)(m-3)x^{m-4}z}{r^m} - 2\frac{(m-1)m^2(m+1)x^{m-2}z}{r^{m+2}} + \frac{m(m+1)(m+2)m+3)x^m z}{r^{m+4}} \right) / 8p^2 \right\} \sin p(bt-r)$$

$$+ \left\{ \frac{m(m-1)x^{m-2}z}{r^{m+1}} - \frac{(m+1)(m+2)x^m z}{r^{m+3}} \right\} / 2p . \cos p(bt-r) + \&c.$$

with a similar expression for ζ, in accordance with (2) which represents a displacement along parallels of spheres having the axis of x for pole.

The resultant displacement represented by the leading term is $\frac{x^m \sqrt{y^2+z^2}}{r^{m+2}}$, the constant which we may call the *strength* of the pole being taken as units to avoid constant repetition of it.

Let us imagine that on a sphere of radius c this displacement is broken up and replaced by a series of secondary waves in the usual manner.

Let P be the point at which we are going to consider the integral displacement, and let the distance of P from the origin be written ρ, and let the direction cosines of the radius of P and the tangents to the meridians and parallel through P of a concentric sphere be given by the scheme.

$$\begin{vmatrix} \cos\alpha \ . & \sin\alpha\cos\beta \ . & \sin\alpha\sin\beta \\ \sin\alpha \ . & -\cos\alpha\cos\beta \ . & -\cos\alpha\sin\beta \\ 0 \ . & \sin\beta \ . & -\cos\beta \end{vmatrix}$$

and let these lines be considered as a new set of axes.

Let OP meet the surface of the sphere of radius c in B, and let the pole of the meridians and parallels be A.

Let Q be any point on the sphere, $c\cos\theta$, $c\sin\theta\cos\phi$. $c\sin\theta\sin\phi$ its co-ordinates referred to the new axes, and let another set of axes through Q be drawn in the direction of the radius produced and tangents to the meridians and parallels through Q referred to axis of x as axis.

They will be given by the scheme

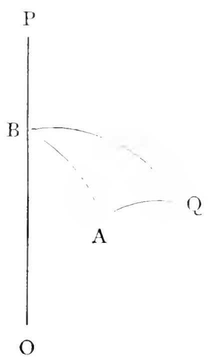
$$\begin{array}{|ccc} \cos\theta\,. & \sin\theta\cos\phi\,. & \sin\theta\sin\phi \\ \sin\theta\,. & -\cos\theta\cos\phi\,. & -\cos\theta\sin\phi \\ 0\,. & \sin\phi\,. & -\cos\phi \end{array}$$

Then the co-ordinates of P, referred to these axes, will be given by $X = \rho\cos\theta - c$

$$Y = \rho\sin\theta$$
$$Z = 0$$

and $r^2 = \rho^2 - 2c\rho\cos\theta + c^2$.

We must now express the amplitude and direction of displacement at Q in terms of a, θ, and ϕ.



Let the angle AOQ be written γ, and the angle between the meridian planes δ. Then

$$\sin\delta\sin\gamma = \sin a\sin\phi;$$
$$\cos\delta\sin\gamma = \cos a\sin\theta - \sin a\cos\theta\cos\phi;$$
$$\cos\gamma = \cos a\cos\theta + \sin a\sin\theta\cos\phi.$$

The first approximation to the resultant displacement at Q is

$$\frac{\cos^m\gamma\sin\gamma}{c};$$

resolving this along the new axes of Y and Z as Q, we get

$$\frac{\cos^m\gamma\sin\gamma\sin\delta}{c} \text{ and } \frac{\cos^m\gamma\sin\gamma\cos\delta}{c} \text{ respectively};$$

and applying to each of these the formulae (1) obtained as the necessary form of displacement in the secondary wave, and writing x and y for X and Y, we get

$$\xi_1 = \cos^m\gamma\sin\gamma\sin\delta f_2(x.r)y - \cos^m\gamma\sin\gamma\cos\delta f_3(x.r)y$$
$$\eta_1 = \cos^m\gamma\sin\gamma\sin\delta\,\phi_1(x.r)$$
$$\zeta_1 = \cos^m\gamma\sin\gamma\cos\delta\{\phi_1(x.r) + \phi_6(x.r)y^2\} + \cos^m\gamma\sin\gamma\sin\delta\,\psi_4(x.r)y^2;$$

all being divided by c.

We must now resolve these parallel to the axes, and get

$$\xi = \xi_1\cos\theta + \eta_1\sin\theta;$$
$$\eta = \xi_1\sin\theta\cos\phi - \eta_1\cos\theta\cos\phi - \zeta_1\sin\phi;$$
$$\zeta = \xi_1\sin\theta\sin\phi - \eta_1\cos\theta\sin\phi + \zeta_1\cos\phi.$$

And each of these is to be affected by $c^2\sin\theta d\theta d\phi$ and integrated between the limits of 0 and 2π for ϕ and 0 and π for θ.

The integration with regard to ϕ is easily done, and we get

ξ depends on f_3 only

η depends on f_3 and ψ_4,

and ζ is the subject of our further investigations.

Resolving again parallel to the original axes we see that to reproduce the original displacement at P we must have

$$\xi = 0, \quad \eta = 0,$$

hence we conclude $f_3 = 0$, $\psi_4 = 0$, and thus have further simplified the formulae (1).

Then

$$\zeta = \int_0^{2\pi}\int_0^{\pi} (\cos a\cos\theta + \sin a\sin\theta\cos\phi)^n c\sin\theta d\theta d\phi$$

$$\times \Big\{ \big(f_2(x.r)y\sin\theta - \phi_1(x.r)\cos\theta\big)\sin a\sin^2\phi$$

$$+ \big(\phi_1(x.r) + \phi_6(x.r)y^2\big)(\cos a\sin\theta - \sin a\cos\theta\cos\phi)\cos\phi \Big\}.$$

The integration with regard to ϕ can be completed thus

$$\int_0^{2\pi} (\cos a\cos\theta + \sin a\sin\theta\cos\phi)^m \sin a\sin^2\phi d\phi$$

$$= \pi\left\{\cos^m a\cos^m\theta\sin a + \frac{m(m-1)}{2.4}\cos^{m-2}a\cos^{m-2}\theta\sin^3 a\sin^2\theta + \text{etc.}\right\}$$

Let us separate in this the parts containing $\cos^m a\sin a$ $\cos^{m-2}a\sin a$, etc., and at the same time change the integral from one with regard to θ to one with regard to r, by writing

$$x + c = \rho\cos\theta.$$

$$y = \rho\sin\theta$$

$$rdr = c\rho\sin\theta d\theta.$$

We thus get as the coefficient of $\pi\cos^m a\sin a/\rho^{m+1}$

$$\int rdr\{ - 2\phi_1(x.r)(x+c)^{m+1}$$

$$+y^2\{f_2(x.r)(x+c)^m+\frac{m(m+1)}{2}\phi_1(x.r)(x+c)^{m-1}-\phi_6(x.r)(x+c)^{m+1}\}$$

$$-y^4\left\{\frac{m(m-1)}{8}f_2(x.r)(x+c)^{m-2}+\frac{3(m+1)\cdots(m-2)}{4\cdot 4\,!}\phi_1(x.r)(x+c)^{m-3}\right.$$
$$\left.-\frac{m(3m+5)}{8}\phi_6(x.r)(x+c)^{m-1}\right\}+\text{etc.}\Big\}$$

The limits between which the integrals are to be taken correspond to the values 0 and π of θ, and depend upon whether the point is within or without the sphere. The expression for $f_2(x.r)y$ is to be the expansion beginning

$$\Sigma c_n x^{n-1} y \sin p\{b(\mathrm{T}+t)-c-r+i\}/r^{n+1},$$

that for $\phi_6(x.r)y^2$ is to be selected out of that beginning

$$\Sigma b_n x^{n-2} y^2 \sin p\{b(\mathrm{T}+t)-c-r+i\}/r^{n+1},$$

and that for $\phi_1(x.r)$ is made up of that part of the preceding which does not contain y, and the expansion beginning

$$\Sigma a_n x^n \sin p\{b(\mathrm{T}+t)-c-r+i\}/r^{n+1}.$$

where T stands for the time at which the displacement reached the surface of the sphere of radius c and t the further time before the secondary wave reaches Q.

Σ denotes summation for different values of n and will be generally omitted, and s and c will be written for

$$\begin{matrix}\sin\\ \cos\end{matrix}\cdot p\{b(\mathrm{T}+t)-c-r+i\}.$$

We expand these by the method previously explained so as to get solutions of the differential equations, these solutions will also satisfy the condition of no condensation if $c_n=-a_n$.

Substitute these expressions in the argument of our integral, and write

$$u_0=-2a_n x^n(x+c)^{m+1}$$
$$+y^2\left\{c_n x^{n-1}(x+c)^m+\frac{m(m+1)}{2}a_n x^n(x+c)^{m-1}-b_n x^{n-2}(x+c)^{m+1}\right\}$$
$$-y^4\left\{\frac{m(m-1)}{8}c_n x^{n-1}(x+c)^{m-2}+\frac{\overline{(m+1)}\cdots\overline{(m-2)}}{32}a_n x^n(x+c)^{m-3}\right.$$
$$\left.-\frac{m(3m+5)}{8}b_n x^{n-2}(x+c)^{m-1}\right\}\text{etc.}$$

u_2 = the expression we should obtain by writing

$$(n-1)(n-2)c_n x^{n-3} \text{ for } c_n x^{n-1}$$
$$(n.(n-1)a_n + 2b_n)x^{n-2} \text{ for } a_n x^n$$
$$(n-2)(n-3)b_n x^{n-4} \text{ for } b_n x^{n-2}$$

u_4 = the expression we should obtain by writing

$$(n-1)\text{---}(n-4)c_n x^{n-5} \text{ for } c_n x^{n-1}$$
$$\{n\text{---}(n-3)a_n + 4(n-2)(n-3)b_n\}x^{n-4} \text{ for } a_n x^n$$
$$(n-2)\text{---}(n-5)b_n x^{n-6} \text{ for } b_n x^{n-2}, \text{ and so on.}$$

Then our integral will take the form

$$\frac{1}{c^{n+1}}\int\left[\left\{U_1 - \frac{U_{-1}}{p^2} + \frac{U_{-3}}{p^4} - \&c.\right\}s + \left\{\frac{V_o}{p} - \frac{V_{-2}}{p^3} + \frac{V_{-4}}{p^5} - \&c.\right\}c\right]dr$$

where

$$U_1 = \frac{u_o}{r^n}$$

$$V_o = \frac{u_2}{2r^{n-1}} - \frac{n(n+1)u_o}{2r^{n+1}}$$

$$U_{-1} = \frac{u_4}{8r^{n-2}} - \frac{(n-1)nu_2}{4r^n} + \frac{(n+1)\text{---}(n+2)u_o}{8r^{n+2}}, \text{ etc.,}$$

and the integral between the proper limits is

$$\frac{1}{\rho^{m+1}}\left[\left\{\frac{v_1}{p} - \frac{v_2}{p^2} + \&c.\right\}c + \left\{\frac{u_2}{p^2} - \frac{u_4}{p^4} + \text{etc.}\right\}s\right]$$

and

$$v_1 = U_1$$

$$u_2 = \frac{dU_1}{dr} - V_0$$

$$v_3 = \frac{d^2U_1}{dr^2} - \frac{dV_0}{dr} + U_{-1}$$

$$u_4 = \frac{d^3U_1}{dr^3} - \frac{d^2V_0}{dr^2} + \frac{dU_{-1}}{dr} - V_{-2}, \text{ etc.}$$

In differentiating with regard to r, we must bear in mind that

$$\frac{dx}{dr} = -\frac{r}{c}, \quad \frac{dy}{dr} = \frac{r(x+c)}{cy}.$$

On differentiating, for example, $\frac{u_o}{r^n}$ let us write the result $\frac{u_o'}{cr^{n-1}} - \frac{nu_o}{r^{n+1}}$, and let us write the subsequent numerators resulting from successive differentiation u_o'', u_o''' etc.

Also let us write

$$u = w + vy^2 + ty^4 + sy^6 + ry^8 + \text{etc.}$$

and differentiate p times, using Leibnitz' Theorem.

$$u^p = (-1)^p\{u^p - 2pv^{p-1}(x+c) - p(p-1)v^{p-2}$$
$$+ 4p(p-1)t^{p-2}(x+c)^2 + 4p(p-1)(p-2)t^{p-3}(x+c) + p\text{---}(p-3)t^{p-4}$$
$$- 8p\text{--}(p-2)s^{p-3}(x+c)^3 - 12p\text{--}(p-3)s^{p-4}(x+c)^2$$
$$- 6p\text{---}(p-4)s^{p-5}(x+c) - p\text{---}(p-5)s^{p-6} + \text{etc.}\}$$

in which y is put zero.

We are now in a position to do the formal integration, as a first step we have the formulae

$$v_1 = \frac{u_o}{r^n}$$

$$u_2 = \frac{u_o'}{cr^{n-1}} + \frac{(n-1)nu_o}{2r^{n+1}} - \frac{u_2}{2r^{n-1}}$$

$$v_3 = \frac{u_o''}{c^2r^{n-2}} + \frac{(n-2)(n-1)u_o'}{2cr^n} - \frac{u_2'}{2cr^{n-2}}$$
$$+ \frac{(n-2)\text{--}(n+1)u_o}{8r^{n+2}} - \frac{(n-2)(n-1)u_2}{4r^n} + \frac{u_4}{8r^{n+2}}$$

$$u_4 = \frac{u_o'''}{c^3r^{n-3}} + \frac{(n-3)(n-2)u_o''}{2c^2r^{n-1}} - \frac{u_2''}{2c^2r^{n-3}}$$
$$+ \frac{(n-3)\text{--}nu_o'}{8cr^{n+1}} - \frac{(n-3)(n-2)u_2'}{4cr^{n-1}} + \frac{u_4'}{8cr^{n-3}}$$
$$+ \frac{(n-3)\text{--}(n+2)u_o}{48r^{n+3}} - \frac{(n-3)\text{--}nu_2}{16r^{n+1}} + \frac{(n-3)(n-2)u_4}{16r^{n-1}} - \frac{u_6}{48r^{n-3}}.$$

In calculating this expression the same kind of series continually presents itself. We may write this series in the general form

$$n(n+1)\text{--}(n+t-1) - p(n+s)(n+s+1)\text{---}(n+s+t-1)$$
$$+ \frac{p(p-1)}{1.2}(n+2s)(n+2s+1)\text{--}(n+2s+t-1) - \text{etc.}$$

Writing

$$n(n+1)\text{--}(n+t-1) = u_n, \text{ and E for } 1 + \Delta,$$

the series becomes

$$\left\{1 - pE^s + \frac{p.(p-1)}{1.2}E^{2s} - \&c.\right\}u_n$$
$$= (1 - E^s)^p u_n.$$
$$= (1 + E + E^2 + \&c. + E^{s-1})^p(-\Delta)^p u_n,$$

and the series is seen to be zero if $p > t$, and if $p = t$ the value of the series is $(-s)^t.t!$

Similarly the series

$$n(n-k)\text{--}(n-(t-1)k) - p(n+k)n(n-k)\text{---}(n-(t-2)k) + \text{etc.}$$
$$= (1 - E^k)^p u_n$$
$$= (1 + E + E^2 + \&c. + E^{k-1})^p(-\Delta)^p u_n$$
$$= 0 \text{ if } p > t.$$
$$= (-1)^t t!\ k^{2t}, \text{ if } p = t.$$

I shall write down the results of the simplifications, in which I have merely treated y as zero and $x^2 = r^2$, but not taken the other steps towards finding the values at the limits.

$$v_1 = -2a_n(x+c)^{m+1}x^n/r^n$$
$$u_2 = 2(na_n + c_n - b_n)x^{n-1}(x+c)^{m+1} + c_n x^n(x+c)^m/cr^{n-1}$$
$$v^3 = -2\{n.(n-1)a_n + 2(n-1)c_n - 2(n-2)b_n\}x^{n-2}(x+c)^{m+1}$$
$$-(m+1)(m+2)(2na_n + c_n - 3b_n)x^{n-1}(x+c)^m$$
$$-\frac{m\text{--}(m+3)}{4}x^n(x+c)^{m-1}/c^2r^{n-2}$$
$$-(m+1)(m+2)((n-1)a_n - 2b_n)x^{n-2}(x+c)^m/cr^{n-2}.$$

In this it will be noticed that (1) $(x+c)^{m+1}$ is the highest power of $(x+c)$ which appears; (2) that c appears to the denominator of every one of these expressions except that for v_1; (3) that the power of r to the denominator is always lower than that of x in the numerator, and that thus any expression such as $\frac{x^{n+1}}{r^n}$ can be written $\frac{x^n}{r^n}(x+c-c)$ or $\frac{x^n}{r^n}(\rho\cos\theta - c)$.

Before we consider the consequences of substituting the values at the limits, we may notice that, as we are taking into account terms which must be neglected unless we profess a minute accuracy, we must not neglect the terms which will arise from other terms than the leading term in the expression for the original wave which was broken up.

Referring to (3) we see that we are considering

$$\xi = 0$$

$$\eta = \left\{\frac{x^m.z}{r^{m+2}} - \frac{m(m+1)(m+2)(m+3)x^m z}{8p^2 r^{m+4}} + \text{etc.}\right\}\sin p(bt-c)$$

$$-\left\{\frac{(m+1)(m+2)x^m z}{2pr^{m+3}} - \text{etc.}\right\}\cos p(bt-c)$$

Writing $V_1.U_2.V_3$, etc., for the coefficients which we get when we take these into account, we get

$$V_1 = -2a_n x^n (x+c)^{m+1}/r^n.$$

$$U_2 = 2(na_n + c_n - b_n)x^{n-1}(x+c)^{m+1}/cr^n$$

$$-(m+1)(m+2)a_n x^{n-1}(x+c)^m/r^{n-1} \text{ etc.}$$

Where we see that in such coefficient we get a part independent of c, and that the coefficients of such terms in order differ only from the coefficients in the corresponding terms of the original expansion by a constant factor. It will be noticed that these coefficients are obtained by integration over the sphere merely, and are quite independent of the special form of expansion which I have used in the secondary wave. The use of that special form of expansion has been to cause the disappearance of all terms from the integral which might have appeared affected by λ/r, and which would have been suitable only in the immediate neighbourhood of the sphere of radius c. We might, in fact, take any constant coefficients in an expansion of the same form, and forming the conditions for the disappearance of the terms in λ/r, etc., infer from their linear character that the form of expansion must be that which I have used.

Also as we shall see later the coefficients independent of c in $V_1.U_2$, etc., can be inferred from the first term of the expanded expression for the original displacement, thus giving additional evidence of the propriety of the form of expansion used.

Proceeding now to the consideration of the actual value of the integral displacement,—if we consider first a point outside the sphere then $\rho > c$, and we need only consider the first coefficient and the wave motion will be reproduced provided

$$\Sigma(-1)^n a_n = 0.$$

$$\Sigma a_n = \frac{1}{\lambda}.$$

$$i = \frac{\lambda}{4}.$$

If we consider a point within the sphere, so long as ρ is a quantity of the same order of magnitude as c, we have no backward wave since $\Sigma(-1)^n a_n = 0$.

If we consider a point near the origin, so that ρ is small compared with c, but bears a finite ratio to λ, so that we may neglect $x+c$ in comparison with x, but retain it $(=\rho\cos\theta)$ when compared with λ, we thus get

$$v_1 = -(-1)^n 2a_n\rho^{m+1}\cos^{m+1}\theta$$

$$u_2 = (-1)^n(m+1)(m+2)a_n\rho^m\cos^m\theta.$$

$$v_3 = -(-1)^n\frac{m\ldots(m+3)}{4}a_n\rho^{m-1}\cos^{m-1}\theta.$$

But the conditions which we have previously obtained ensure that each of these will vanish.

The sole condition which we find then to ensure that the system of secondary waves, of which we have previously obtained the form, should reproduce a spherical wave is $\Sigma(-1)^n a_n = 0$, provided that λ/c should be a very small quantity, which is a condition essential to the very consideration of the matter.

Here it will be noticed that the coefficients of $\Sigma(-1)^n a_n$ at a point near the origin are the coefficients of the corresponding terms in the originally used expansion. These now appear as deduced from the first term of that expansion, and are independent of n and do not depend upon the method by which the expansions were formed, but appear solely as a result of integration.

If the wave were travelling inwards towards the centre, we should find the solution reproduced in its entirety as ρ approaches the value λ.

The solution is still left indefinite; to make it definite in the last part of this paper I shall consider values of $\rho < \lambda$. It is needless to consider the general case of displacement of a sphere, it offers no further difficulties and gives no further conditions.

If we had, in what precedes, integrated only over that part of the spherical surface which presents itself to P (a case which in the limit corresponds to the integration over an infinite plane), we should have obtained in addition to the principal terms already treated, terms arising from the boundary of which the only part sensible would be

$$\frac{b_2}{\rho}\cos p\{b(T+t)-c-y+i\},$$

which corresponds to the value 2 of n, and in which y stands for the length of the tangent from the point to the sphere. This term is of the same order of quantities as the terms which we have called principal terms. In the last part of this paper I attempt to show that $b_2 = 0$.

Note.—It might be objected that the displacement, but not the velocity of displacement has been here considered. But our expressions will give the requisite velocity of displacement, as may be easily proved. It must be remembered that we are attempting to satisfy the conditions of motion by expressions into which the time enters only in the form $\phi\left(t-\frac{r}{b}\right)$, in other words by a divergent wave. Hence, if the expressions which we obtain do not satisfy the conditions, we should infer that the problem could not be solved by expressions of the form $\phi\left(t-\frac{r}{b}\right)$. We have in this case one function only to be introduced, and the displacement and velocity of displacement initially satisfy the equations of motion which we are solving.

Taking Poisson's solution of the equation $\left(\frac{d^2}{dt^2}-b^2\nabla^2\right)\phi=0$, and expanding it (noticing that $\cos\theta.\sin\theta\cos\phi$ and $\sin\theta\sin\phi$, being arbitrarily chosen are interchangeable) we arrive at the symbolic solution of the differential equation

$$\phi = \cos(ibt\nabla)f + \frac{\sin(ibt\nabla)}{ib\nabla}F$$

where f and F denote the initial values of ϕ and $\dot{\phi}$.

But if f and F initially belong to a state of motion satisfying the differential equation, then

$$(b^2\nabla^2 + k^2)f = 0 \qquad (b^2\nabla^2 + k^2)F = 0.$$

and the solution simplifies to

$$\phi = f\cos kt + \frac{F\sin kt}{k}$$

in accordance with an ordinary consideration of a Fourier expansion, and shows that ϕ has the form of a function of

$$\left(t - \frac{r}{b}\right).$$

§ 4.

The relation between the displacement and rotation at any point of a spherical wave are such that if V and W are the coefficients in the components of the displacement along the tangents to the meridian and parallel at the point, then pW/2 and $-p$V/2 are the corresponding coefficients in the components of the rotation, the trigonometrical terms having been omitted for brevity.

Continuing to omit the trigonometrical terms, let us form the expression for the secondary wave from the displacement, and then form the expression for the rotation in the secondary wave. Thus we get

$$2X/p = Vx^{n-2}z\{a_n x^2 + b_n(r^2 - x^2)\} \quad - Wx^{n-2}y\{a_n x^2 + b_n(r^2 - x^2\}$$
$$2Y/p = -V(b_n - a_n)x^{n-1}yz \qquad + Wx^{n-1}\{a_n(x^2 + z^2) + b_n y^2$$
$$2Z/p = -V(x^{n-1}\{a_n(x^2 + y^2) + b_n z^2 + W(b_n - a_n)x^{n-1}yz$$

all divided by r^{n+2}.

It is more convenient to write these

$$2X/p = -W(a_{n-1} - b_{n-1} + b_{n+1})x^{n-1}y + \text{etc.}$$
$$2Y/p = \quad W\{(a_{n-1} - b_{n-1} + b_{n+1})x^n + (a_{n-1} - b_{n-1})x^{n-2}z^2\}\text{etc.}$$
$$2Z/p = -W(a_{n-1} - b_{n-1})x^{n-2}yz - \text{etc.}$$

all divided by r^{n+1}, where I have omitted the terms relating to V which are identical in form with those retained.

We may now argue that if for any reason the values of n and of the coefficients a_n and b_n are determinate in the expressions for the displacement, we shall have the same determinancy about the coefficients in the expressions for the rotation which is a vector of identical form. Or we may form the expressions for the secondary wave representing the original rotation, which ought to agree with that just written not only when the integration is performed over the whole surface of the sphere, but if extended over any portion of it.

By either line of reasoning we should conclude that

$$a_{n-1} - b_{n-1} + b_{n+1} = a_n$$
$$a_{n-1} - b_{n-1} \qquad = b_n$$

If p be the least value of n, we get

$$a_p = b_{p+1}$$
$$b_p = 0,$$
$$b_{p+2} = a_{p+1} - a_p$$
$$b_{p+3} = a_{p+2} - a_{p+1} + a_p$$

and finally

$$a_p - a_{p+1} + a_{p+2} - \text{etc.} = 0, \text{ or } \Sigma(-1)^n a_n = 0.$$

From this we conclude that if 2 is the least value of n

$$b_2 = 0,$$

as we have said before it is reasonable to expect, and of which a proof will be offered in the next section.

§ 5.

We have as yet considered a solution of the fundamental differential equation which proceeds by powers of λ/r and is convergent if $r>\lambda$, but which is not only infinite when $r=0$, but is also still a function of the direction of the vanishing vector. It is, however, evident that there is also a solution in ascending powers of r/λ, which will not be a terminating series: these two series must give us no discontinuity when $r=\lambda$.

Instead of trying to satisfy this condition, let us imagine that a displacement directed along the axis of y, and propagated along that of x, is broken up at the origin, and geometrically represented at a distance from the origin by a secondary spherical wave of the form which has been considered in this paper. Let us imagine also that this secondary wave has travelled till its displacements lie on a sphere of radius c which is large compared with λ, so that the first terms are the only terms which are sensible, and then imagine the velocities reversed, so that, since the forces acting in the medium depend upon displacements and not on velocities, the wave will reverse its course tracing out its previous history in reversed order, and let us examine the nature of the resulting motion at the origin.

In general terms we know that we shall obtain a wave converging to the origin and then diverging outwards again. Our notation being the same as before, imagine the sphere of radius c to be drawn, and that the displacements upon it at a point $(x.y.z)$ are given by

$$\xi = -\Sigma A_n x^{n-1} y / c^{n+1}$$
$$\eta = \Sigma (A_n x^n + B_n x^{n-2} z^2) / c^{n+1}$$
$$\zeta = -\Sigma B_n x^{n-2} y z / c^{n+1},$$

each affected by

$$\sin p \left\{ b(T + t_o) - c + \frac{\lambda}{4} \right\}$$

where $c = bt_o$ and $a_n . b_n$ have been replaced by $A_n . B_n$ to avoid confusion in what follows.

Call the point at which this displacement exists Q, and the point at which we are to consider the displacement P, of which the co-ordinates are $\rho \cos \alpha$, $\rho \sin \alpha \cos \beta$, $\rho \sin \alpha \sin \beta$, where ρ is to be small compared with λ and still more so compared with c.

Take new axes of which the axis of x passes through P as before, let the co-ordinates of Q relative to these axes be $c\cos\theta$, $c\sin\theta\cos\phi$, $c\sin\theta\sin\phi$, and imagine new axes as before to be drawn through Q, then

$$x = c\{\cos\alpha\cos\theta + \sin\alpha\sin\theta\cos\phi\}$$
$$y = c\{(\sin\alpha\cos\theta - \cos\alpha\sin\theta\cos\phi)\cos\beta + \sin\theta\sin\phi\sin\beta\}$$
$$z = c\{(\sin\alpha\cos\theta - \cos\alpha\sin\theta\cos\phi)\sin\beta - \sin\theta\sin\phi\cos\beta\}$$

and if ${}_\xi U_{-1}$, ${}_\eta U_{-1}$, ${}_\zeta U_{-1}$, denote the coefficients of the trigonometrical function in the components of the displacement at Q resolved along the axes through Q,

$$\xi U_{-1} = 0$$
$${}_\eta U_{-1} = A_n x^{n-1}\{\cos\beta\cos\phi - \sin\beta\sin\phi\cos\alpha\}/c^n$$
$$- B_n x^{n-2} z\sin\alpha\sin\phi/c^n$$
$$\zeta U_{-1} = -A_n x^{n-1}\{\cos\beta\cos\theta\sin\phi + \sin\beta(\sin\alpha\sin\theta + \cos\alpha\cos\theta\cos\phi)\}/c^n$$
$$+ B_n x^{n-2} z(\cos\alpha\sin\theta - \sin\alpha\cos\theta\cos\phi)/c^n,$$

where I have retained x and z for brevity.

We are to regard these now as expressing the coefficients of the displacements in a wave converging to the origin, and each element of this wave is to be replaced by a secondary wave in the same way as the original wave was replaced by a secondary wave.

Write

$$X = c - \rho\cos\theta,$$
$$Y = \rho\sin\theta,$$
$$Z = 0.$$
$$r^2 = X^2 + Y^2 + Z^2 = c^2 - 2c\rho\cos\theta + \rho^2$$
$$r = c - \rho\cos\theta.$$

Hence the components of the secondary wave arising from the element at Q resolved along the axes through Q are

$$\xi_1 = \Sigma_\eta U_{-1} a_k X^{k-1} Y \sin p\left\{b(T + t_0 + t) - c + r + \frac{\lambda}{2}\right\}/r^{k+1}$$
$$\eta_1 = \Sigma_\eta U_{-1} a_k X^k \sin p\left\{b(T + t_0 + t) - c + r + \frac{\lambda}{2}\right\}/r^{k+1}$$
$$\zeta_1 = \Sigma_\eta U_{-1}(a_k X^k + b_k X^{k-2} Y^2)\sin p\left\{b(T + t_0 + t) - c + r + \frac{\lambda}{2}\right\}/r^{k+1},$$

where I have written the first term only of the expansion and k has the same range of values as n and $a_k = A_k$, $b_k = B_k$.

These displacements must now be resolved along a set of fixed axes, most conveniently that set of which the axis of x passes through P, thus

$$\xi_2 = \xi_1\cos\theta + \eta_1\sin\theta$$
$$\eta_2 = \xi_1\sin\theta\cos\phi - \eta_1\cos\theta\cos\phi + \zeta_1\sin\phi$$
$$\zeta_2 = \xi_1\sin\theta\sin\phi - \eta_1\cos\theta\sin\phi - \zeta_1\cos\phi.$$

We shall then have to affect each element of these expressions by $c^2\sin\theta d\theta d\phi$ and integrate over the whole sphere. I have retained ρ in the expressions up to this point to show that we do not get an infinite expression when ρ is small, but an expression proceeding in powers of ρ/λ. I shall now, however, put $\rho=0$, and consider the displacement at the origin only.

Hence, remembering that $\Sigma a_k = \frac{1}{\lambda}$, we get

$$c^2\iint \xi_2\sin\theta d\theta d\phi$$
$$= -\frac{1}{\lambda}\sin pb(T+2t_o)\iint {}_{\eta}U_{-1}\sin^2\theta d\theta d\phi$$

$$c^2\iint \eta_2\sin\theta d\theta d\phi = \frac{1}{\lambda}\sin pb(T+2t_o)\times$$
$$\left\{\iint {}_{\eta}U_{-1}\sin\theta\cos\theta\cos\phi d\theta d\phi - \iint {}_{\zeta}U_{-1}\sin\theta\sin\phi d\theta d\phi\right\}$$

$$c^2\iint \zeta_2\sin\theta d\theta d\phi = \frac{1}{\lambda}\sin pb(T+2t_o)\times$$
$$\left\{\iint {}_{\eta}U_{-1}\sin\theta\cos\theta\sin\phi d\theta d\phi + \iint {}_{\zeta}U_{-1}\sin\theta\cos\phi d\theta d\phi\right\}$$

The values of these integrals depend on the value of n. For the case $n=2$.

$$\iint {}_{\eta}U_{-1}\sin^2\theta d\theta d\phi = \frac{4\pi}{3}(A_2+B_2)\sin\alpha\cos\beta.$$

$$\iint {}_{\eta}U_{-1}\sin\theta\cos\theta\cos\phi d\theta d\phi - \iint \zeta U_{-1}\sin\theta\sin\phi d\theta d\phi$$

$$= +\frac{4\pi}{3}(A_2+B_2)\cos\alpha\cos\beta$$

$$\iint {}_{\eta}U_{-1}\sin\theta\cos\theta\sin\phi d\theta d\phi + \iint \zeta U_{-1}\sin\theta\cos\phi d\theta d\phi$$

$$= -\frac{4\pi}{3}(A_2 + B_2)\sin\beta.$$

It is obvious that this represents a displacement of the same nature as the original displacement, namely along the original axis of y.

When $n = 3$ we get no component.

When $n = 4$ the displacement at the origin assumes a different direction, and we are therefore led to consider the admissible values of n to be 2 and 3.

To determine the nature further—the original displacement being $\sin p(b\mathrm{T} - x)$ directed along the axis of y, the rotation is given by $-\frac{p}{2}\cos p(b\mathrm{T} - x)$. And if we form the expression for the rotation in the secondary wave, and then find the integral rotation at the origin, it should be related to the original rotation as the integral displacement at the origin is to the original displacement. The expressions for the rotation in the secondary waves are:

$$2X_1 = 0.$$

$$2Y_1 = p\Sigma\zeta U_{-1}\cos p\left\{b(\mathrm{T} + 2t_o) + \frac{\lambda}{2}\right\}/\lambda c^n$$

$$2Z_1 = -p\Sigma_\eta U_{-1}\cos p\left\{b(\mathrm{T} + 2t_o) + \frac{\lambda}{2}\right\}/\lambda c^n.$$

We must resolve these along the fixed axes as before, and integrate over the whole sphere.

Thus

$$X_2 = Y_1\sin\theta$$

$$Y_2 = -Y_1\cos\theta\cos\phi + Z_1\sin\phi$$

$$Z_2 = -Y_1\cos\theta\sin\phi - Z_1\cos\phi.$$

Pursuing the integration we now see that we get no component corresponding to $n = 2$, and that when $n = 3$ the resultant rotation will not have the suitable direction unless $A_3 = B_3$.

We in that case have

$$_\zeta U_{-1} = -A_3 x\{\sin\beta\cos\phi + \cos\alpha\cos\beta\sin\phi\}$$

$$_\eta U_{-1} = A_3 x\{(\sin\alpha\sin\theta + \cos\alpha\cos\theta\cos\phi)\cos\beta - \sin\beta\cos\theta\sin\phi\}$$

$$\therefore 2c^2\int\int X_2 \sin\theta d\theta d\phi$$

$$= \frac{4\pi}{3} p A_3 \sin\alpha\sin\beta\cos pb(T - 2t_o)/\lambda.$$

$$2c^2\int\int Y_2 \sin\theta d\theta d\phi$$

$$= -\frac{4\pi}{3} p A_3 \cos\alpha\sin\beta\cos pb(T + 2t_0)/\lambda.$$

$$2c^2\int\int Z_2 \sin\theta d\theta d\phi$$

$$= -\frac{4\pi}{3} p A_3 \cos\beta\cos pb(T + 2t_o)/\lambda.$$

This integral rotation has the same direction as the original rotation: as far as concerns the actual magnitude, it is obvious from the outset that the displacement in the secondary wave will be of -2 dimensions in space. Without speculating upon the absolute relation between the original displacement at the origin, and the integral displacement here found, it seems reasonable to expect that the relationship between the original and integral displacement should be the same as that between original and integral rotation.

This requires that $A_3 = A_2 + B_2$.

Taking this in connection with the conditions previously obtained, viz.:

$$n = 2 \text{ and } 3.$$

$$A_2 = A_3.$$

$$A_2 + A_3 = \frac{1}{\lambda}.$$

we have as our final determination.

$$B_2 = 0.$$

$$A_2 = A_3 = B_3 = \frac{1}{2\lambda}.$$

and the form of displacement in the secondary wave is found to be

$$\xi = -\left\{\frac{xy}{r^3} + \frac{x^2y}{r^4}\right\}\sin\frac{2\pi}{\lambda}(bt - r)/2\lambda.$$

$$\eta = \left\{\frac{x^2}{r^3} + \frac{x^3 + xz^2}{r^4}\right\}\sin\frac{2\pi}{\lambda}(bt - r)/2\lambda.$$

$$\zeta = -\frac{xyz}{r^4}\sin\frac{2\pi}{\lambda}(bt - r)/2\lambda.$$

The resultant displacement being

$$\frac{x(x + r)}{2\lambda r^3}\sin\frac{2\pi}{\lambda}(bt - r).$$

MICROSCOPICAL AND NATURAL HISTORY SECTION.

Ordinary Meeting, January 16th, 1888.

Professor W. C. WILLIAMSON, F.R.S., President of the Section, in the Chair.

Mr. W. LEACH was elected an associate of the Section.

Mr. H. HYDE exhibited the following uncommon plants: *Camelina sativa; Neslia paniculata; Saponaria vaccaria; Silene dichotoma;* and *Salvia verticillata;* all found on a refuse heap on the canal bank at Bollington, Cheshire, in 1886; also *Lepidium latifolium*, found on the site of the new museum, South Kensington; and *Galinsogea parviflora*, which grows abundantly about Kew.

Mr. P. CAMERON exhibited a new species of *Phyllotoma*, from Norwich, which he proposes to name *Phyllotoma fumipennis*, Cameron. It comes nearest to the poplar leaf-miner *Phyllotoma ochropoda*, but is very distinct from it in the colour of the tegulæ, legs, and wings, and in the form of the head.

Dr. ALEX. HODGKINSON gave a communication on the effects of diamond cuts on glass.

The PRESIDENT described some anomalous cellular structures developed within the vascular cellular tissues of some of the plants of the Coal measures.

Mr. W. L. TORRANCE exhibited a series of photographs from Java.

PHYSICAL AND MATHEMATICAL SECTION.

Ordinary Meeting, January 18th, 1888.

Dr. BOTTOMLEY in the Chair.

Dr. BOTTOMLEY stated that he wished to call attention to an error in his paper, " On the Composition of projections in geometry of two dimensions," published in Vol. X., 3rd series of the Society's Memoirs; on page 15, it is stated that the perimeter of the ellipse

$$m^2(x-a)^2+4ml(x-a)y+(4-3m^2)y^2=m^4c^2$$

is equal to the perimeter of the circle

$$(x-a)^2+(y-b)^2=c^2$$

from which it is derived—this, however, is not correct, the axes of the ellipse are $c(1+l)$ and $c(1-l)$, and the statement holds only in the case when $l=0$, it will, however, be approximately true if l be a very small quantity, using a method of approximation adopted in some mathematical tables.

Ordinary Meeting, January 24th, 1888.

Mr. CHARLES BAILEY, F.L.S., in the Chair.

DR. BOTTOMLEY read an additional note on "The equations expressing the decomposition of Potassic Chlorate by heat." He said:—

In a previous note, published in the current volume of *Proceedings and Memoirs*, the general equation was written as follows:—

$$2PKClO_3 = 2QKClO_4 + 2(P - Q)KCl + (3P - 4Q)O_2.$$

A more convenient form would, I think, be obtained by dividing both sides by 2, giving the following equation:—

$$PKClO_3 = QKClO_4 + (P - Q)KCl + \frac{(3P - 4Q)}{2}O_2.$$

This form admits of a greater number of solutions with a given number of molecules of $KClO_3$ than the previous form. It also imposes a new condition on the values of P; they must be even numbers. If P = 22, in addition to the equations given in a previous note the following are possible:—

$$\begin{aligned} 22KClO_3 &= KClO_4 + 21KCl + 31O_2 \\ &= 3KClO_4 + 19KCl + 27O_2 \\ &= 5KClO_4 + 17KCl + 23O_2 \\ &= 7KClO_4 + 15KCl + 19O_2 \\ &= 9KClO_2 + 13KCl + 15O_2 \\ &= 11KClO_4 + 11KCl + 11O_2 \\ &= 13KClO_4 + 9KCl + 7O_2 \\ &= 15KClO_4 + 7KCl + 3O_2 \end{aligned}$$

making in all, with those previously given, sixteen equations (excluding the value Q = O).

Dr. BOTTOMLEY also introduced the subject of Mendelejeff's recent paper on the compounds of ethyl-alcohol and water, published in the *Journal of the Chemical Society* for

October last, and referred to the Russian chemist's mathematical method for determining the presence of definite compounds.

Dr. HODGKINSON made a communication on phenomena associated with diamond cuts on glass.

Professor H. B. DIXON made a communication "On the Union of Hydrogen and Nitrogen." He said:—

In 1877, when I was demonstrator in Dr. Lee's laboratory at Christ Church, Oxford, I assisted Mr. A. Vernon Harcourt in an experiment in which we endeavoured to bring about the combination of nitrogen and hydrogen by the silent discharge. Contrary to the statement of Mr. W. F. Donkin (*Proc. Roy. Soc.* xxi. 281) we found no trace of ammonia formed. Mr. S. Johnson has more recently expressed the opinion that nitrogen exists in two allotropic modifications, the first of which more easily unites with hydrogen than the second; and that the action of heat on the first variety is to turn it into the second. According to this view, the nitrogen prepared by passing air and ammonia over heated copper and copper oxide (Mr. Harcourt's method) would consist wholly of the second or inactive variety, and would not unite with hydrogen to form ammonia. The existence, however, of these two varieties of nitrogen has not, I believe, been confirmed by other chemists. Mr. Harcourt has recently informed me that, finding the decomposition of ammonia to be appreciably incomplete when induction sparks are passed through the dry gas over mercury, he was led to the conclusion that the same sparks must bring about the union of hydrogen and nitrogen to an appreciable extent. This conclusion he has verified by experiment.

I have repeated this experiment in a eudiometer with platinum-iridium electrodes 2 mm. apart. 30 cc. of a mixture of dry hydrogen and nitrogen* were collected over

* The nitrogen was prepared from air by passing it over red hot copper.

mercury in the eudiometer, and 2 cc. of oil of vitriol were passed up to the top of the mercury. On passing sparks from the coil the mercury steadily rose in the tube, until after 35 minutes the liquid had risen to the wires, and only 5 cc. of the gases remained uncombined. Mr. Harcourt's experiment can therefore be readily shown to a class during a lecture. The experiment is really similar to that made by Deville, who found that hydrogen and nitrogen had the power of combining under the influence of the electric spark in the presence of gaseous hydrochloric acid. Deville considered that the hydrochloric acid conferred the power of combination on the hydrogen and nitrogen: no doubt the hydrochloric acid in his experiment, as the sulphuric acid in ours, removed the ammonia as it was produced, and presented the occurrence of the reverse change, viz.:—the splitting up of the ammonia into its constituents.

In Mr. Donkin's experiment the sparks of the "silent discharge" were presumably of greater intensity than those employed by us in 1877, for ordinary induction sparks bring about a rapid combination, whereas our silent discharge was ineffective.

Dr. SCHUSTER gave the results of some researches by Prof. Hann, of Vienna, and others, showing that the temperature in the centre of an anti-cyclone is higher than on its edge at heights above 1,500 feet, while at the sea level it is lowest in the centre.

General Meeting, February 7th, 1888.

Professor OSBORNE REYNOLDS, LL.D., M.A., F.R.S., Vice-President, in the Chair.

Mr. Alderman W. H. BAILEY, of Salford, and Mr. WILLIAM GRIMSHAW, of Manchester, were elected ordinary members.

Ordinary Meeting, February 7th, 1888.

Professor OSBORNE REYNOLDS, LL.D., M.A., F.R.S., Vice-President, in the Chair.

Mr. JOHN ANGELL, F.C.S., F.I.C., and Mr. ALEX HODGKINSON, M.B., B.Sc., were appointed Auditors of the Treasurer's Accounts.

Mr. CHARLES BAILEY, F.L.S., referred to the recent deaths of Dr. A. de Bary and Dr. Asa Gray, two of the honorary members of the Society; the one a leading representative of botanical physiology in the eastern hemisphere, and the other the most distinguished botanical systematist of the western hemisphere. Both had been our guests in September last, and by their genial manners and their readiness to impart their great stores of knowledge, had endeared themselves to a widening circle of old and of new friends. Both had taken a prominent part in the proceedings of the Biological Section of the British Association's meeting in Manchester. Both of them left us to die in the homes of their fathers; but

'To live in hearts we leave behind,
Is not to die.'

The younger of the two predeceased the elder, and many of us who welcomed him to Manchester parted from him with pain, from the knowledge we had of the mortal disease from which he was suffering, and which had just begun to take an acute form during the later days of his stay in Manchester. The Strassburg professor, Dr. Anton de Bary, was born on the 26th January, 1831, in the city of Frankfort, and, after holding the chairs of Botany successively at Freiburg, Halle, and Strassburg, died in the last-named city on the 19th January, 1888. During the last 35 years of his life of 57 years he contributed a succession of solid and original papers upon almost all departments of vegetable physiology, but with a decided bias towards investigations in the morphology and structure of the cellular cryptogams. These researches led to his selection by the Royal Agricultural Society of England to conduct an exhaustive inquiry into the nature and origin of the potato disease, which had been committing such ravages in these islands; and though this appointment led at the time to a few ill-natured remarks about the inquiry being entrusted to a foreigner, the results justified the wisdom of the selection. De Bary's editorship of the weekly *Botanische Zeitung* (which comes regularly to the Society) showed how wide were his acquirements in all departments of botanical science. The book which perhaps more than any other would be selected by the speaker as illustrating his judicial mind and his insight into first principles is his "Comparative Anatomy of the Vegetative Organs of the Phanerogams and Ferns." This work discloses a vast array of isolated facts, splendidly marshalled, and largely based upon his own observations and illustrations (for he was an accomplished artist on wood); and yet in a treatise of such erudition, disclaiming criticism, he had the modesty to write, "that every word in this book has had a previous author, printer, and publisher"! Such was the spirit of the man whose death is sincerely mourned by botanists of every nationality.

The elder of the two, whom to know was to love—for he was as celebrated for his goodness as for his science—was a man who worked in quite different fields from de Bary. Though he was, confessedly, head and shoulders above the rest of American botanists, Botany could not claim Dr. Asa Gray as exclusively her own. Darwin appreciated his many-sidedness by writing of him and to him, "You are a hybrid, a complex cross of lawyer, poet, naturalist, and theologian." Born at Paris, Massachusetts, 18th November, 1810, he died at Cambridge, U.S., 30th January, 1888. The unique position which he held amongst American botanists largely controlled the direction of his work, for the wide extent of new territory constantly being explored on his native continent brought with it the duty of describing multitudes of new forms and species. Hence, it is in descriptive and geographical rather than in physiological botany that the monument of Gray's genius and labours will ultimately rest. But the personality of the man was greater than his work, and will never be forgotten by his contemporaries. A namesake of the speaker's, writing from Providence, and testifying from personal knowledge, says: "His presence among men was a benediction. In the summer classes, when the good Doctor entered the laboratory, he seemed to bring with him the blessed light of heaven. The room grew suddenly darker as he withdrew. All desired to see him. Strangers would wait in the garden to catch a glimpse of the venerable head at his favourite working window." A most grateful tribute of appreciative respect was paid to the 'old man eloquent' on the occasion of his 75th birthday, by the presentation of an elegant silver vase and salver, upon which were embossed the plants that are associated with his name. Notwithstanding his weight of years, Dr. Asa Gray was ever young in spirit, and he was as approachable to the little child as to the most diffident of his university pupils, as well as helpful and genial to all who sought his help. He was among the most sprightly and merry of all our visitors to the British Association; and those of us who assembled to be photographed in the group of distinguished vegetable physiologists attending the meeting, will not forget the exuberance of spirits manifested by our revered friend respecting our desire that his charming wife should be included in the group. This photograph is already a memorable picture: in its centre is the Society's former president and a present vice-president, Dr. W. C. Williamson; on his right hand sits de Bary, on his left hand Asa Gray! Both are now gone from us, and we shall see their living faces no more. Upon whom will Death next shoot his arrow? Whoever he may be, so let him have used his opportunities for enlarging the bounds of human knowledge to the extent of his capacity as did our two recent venerated guests!

Mr. BAILEY could not permit the occasion to pass without paying a tribute of respect to the memory and work of a British botanist who died almost at the same time as Dr. Asa Gray, viz., Dr. J. T. Boswell (formerly Syme), the well-known author of the scientific text of the third edition of "Sowerby's English Botany," which is a masterpiece of descriptive analysis and arrangement of our native phanerogams and vascular cryptogams. Few men had paid more attention to the critical varieties of our native plants, or had so many of such plants passing through his hands for determination. His keen characterisation of their forms, and study of their facies, gave a great impetus to the younger generation in investigating the directions of variability in the living plant, and of the comparative area which each species occupies in our islands. Laborious and conscientious to a fault in all his botanical work, his opinions and verdicts, in consequence, were held in great esteem by all British botanists. Though living in the midst of many keen, and sometimes bitter, botanical tournaments, he was entirely free from partisanship, and however keenly he would follow the merits of the controversy, he never took part in the strife. The speaker gratefully acknowledged how much his quiet influence had controlled the direction and spirit of his own studies, and none of his pupils would more sincerely mourn his death. Dr. Boswell was born in Edinburgh on the 1st December, 1822, and died at his family estate, Balmuto, Fifeshire, on the 29th January, 1888. He lectured on botany for many years to the students of the Charing Cross School of Medicine, and afterwards at Westminster Hospital. His honorary degree of LL.D. was conferred upon him by the University of St. Andrews.

Mr. THOMAS KAY communicated a "Note on an erratic block observed during excavations for a sewer in Oxford Street, Manchester," by PERCY F. KENDALL, Assistant Lecturer on Geology in the Owens College, Manchester.

Mr. KENDALL said that the boulder was met with in the course of the excavation for a new sewer, and his attention was drawn to it by Mr. Jones, who was supervising the work on behalf of the Corporation, and to whom the geologists of the district were greatly indebted, as it was through his instrumentality that nearly all large boulders placed in our public Parks have been secured. The stone was found embedded in the base of the boulder clay, just at the junction with an underlying bed of gravel. Its extreme dimensions were about 9ft. 6in. × 7ft. 4in. × 5ft. 10in. Such large boulders offered much more striking evidence of ice-transport than those of small size, as we know of no other natural agent competent to effect their removal to great distances from the parent rock. An inspection of the rock showed that it was identical in character with the most abundant rock among the smaller boulders of the neighbourhood, viz.: a volcanic rock of the andesitic type. As to the place of origin of the rock—he had found among the small specimens some which contained fragments of rhyolite lava enclosed in andesite, and as such an association is of rare occurrence in Britain, he thought the fact that andesites and rhyolites were to be seen in the country about Honister and Coniston, might be accepted as evidence of the derivation of the boulder from that part of the Lake District. He had indeed seen specimens which were indistinguishable in appearance from the example under consideration. The specific gravity of the rock was about 2·75, which would indicate a weight of about 170lbs. per cube foot. The weight of the boulder might be taken as between 20 and 30 tons. He added some observations upon the question of a vertical circulation in the glacier-ice, which might possibly account for the fact recorded by Mr. J. G. Goodchild that transported blocks have been found at an altitude of 1,000 feet above the parent rock, though at a distance of 5 or 6 miles.

Mr. FARADAY alluded to the perched blocks on Norber, a spur of Ingleborough, and suggested that the Craven district was worth considering as a possible source of travelled blocks found in this neighbourhood.

MICROSCOPICAL AND NATURAL HISTORY SECTION.

Ordinary Meeting, February 13th, 1888.

The President, Professor WILLIAMSON, F.R.S., in the Chair.

Mr. H. L. EARL, B.A., Manchester Grammar School, was elected an associate of the section.

There were exhibited :—

By Mr. R. C. CUNLIFFE,—Volcanic dust, from Krakatoa in the Straits of Sunda, and from Tarawera in New Zealand.

By Mr. THOS. ROGERS,—specimens of the pearl mussell, *Unio margaritifer*, from the river Lune ; the only recorded locality for this species in Lancashire. First discovered by David Dyson about forty years ago, and re-discovered by Robert Standen in 1887.

By Mr. H. C. CHADWICK,—specimens of three species of *Bagula*.

By Mr. H. HYDE,—specimens of Chalk, from the Brighton coast, and from the Channel tunnel.

By Mr. J. C. MELVILL,—the ♀ of a Hymenopterous insect from West Columbia, of which the ovipositer was of the extraordinary length of 5½ inches, the insect itself being less than three-quarters of an inch long.

The PRESIDENT described two forms of reproductive gemmules developed on the roots of two species of mosses grown in one of his hot-houses. One of these mosses was *Webbera nutans*, on which these gemmules were pyriform. The other was an undetermined moss,on which the gemmules were circular like those figured in the *Lehrbuch* of Sachs.

By Mr. JOHN BOYD,—two quaint old microscopes. One presented to the section in 1873 by Mr. Rideout; the other, believed to be John Dalton's, made by B. Martin, London, which is the property of the Society.

Dr. HODGKINSON exhibited and explained, "A prismatic chart for determining the characteristics of interference colours."

Notes on a Small Collection of Mosses from Mauritius.

By J. Cosmo Melvill, M.A., F.L.S.

(Received February 13, 1888.)

For the last three or four years I have from time to time received various botanical collections, mostly Cryptogamic, from the island of Mauritius. In 1885 two very interesting parcels of Marine Algæ arrived, which I submitted to Prof. J. G. Agardh, of Lund, Sweden, the result of his investigations being that no less than twelve species—and these among the most conspicuous and showy kinds mainly—were described by him as new to science. And last July I came into possession of a collection of Musci from the same source, with a few Ferns and Hepaticæ, intermingled.

The ferns sent are very meagre; Mr. J. G. Baker, F.R.S., of Kew, detected one common species of Polypodium and three of Trichomanes:—T. cuspidatum (Willd) = Bojeri (Hooker) endemic to Mauritius and Bourbon, T. Filicula (Bory) = bipunctatum (Poiret) which latter name has priority, a very widely-distributed fern, and T. trinerve (Baker), a recently described and rare species, not occurring elsewhere.

The Mosses have all been carefully examined by Mr. Henry Boswell, M.A., of Oxford, one of our highest authorities on this group of plants, and for the following discriminations my best thanks are due. He informs me that such collections from this island have very rarely come hitherto to this country, and that the only collectors there during the past twenty years have been Mr. Pike and M. Robillard, both well known for their researches amongst the Mollusca and other branches of Zoology as well. From M. Robillard's specimens most of the known endemic Mauritian mosses have been described, mainly by Herr C. Müller. Many of these will be found to occur in the collection now under notice. It is to be regretted that very few show any signs of fructification. Only one species, Hildenbrandtiella nitens (Boswell MSS.) is actually a novelty, but several are almost unknown in Herbaria. This will probably be described in the *Journal of Botany* before many weeks elapse.

Musci (*a*) Acrocarpi.

Fam.: *Dicraneæ.*

1. Campylopus brachymastix (C. Müller).
2. „ chlorotrichus „
3. „ sp.
4. Leucoloma amblyacron (C. Müller.)
5. „ persecundum „
6. „ sinuosulum „

Fam.: *Leucobryeæ.*

7. Octoblepharum albidum (L).

Fam.: *Orthotricheæ.*

8. Macromitrium aciculare (Schweg).
9. „ sp. nisi in fructu haud cognoscendum.
10. „ sp. „

11. Macromitrium laxotorquatum (C. Müller).
12. Schlotheimia Robillardi (C. Müller).

Fam.: *Bartramiece.*

13. Philonotis tenuicaulis (Hampe).

Fam.: *Bryeæ.*

14. Bryum nanorhodon (C. Müller.)
15. „ sp.
16. Rhizogonium spiniforme (L.).

MUSCI (*b*) PLEUROCARPI.

Fam.: *Hypopterygieæ.*

17. Hypopterygium pugiunculus (Boswell MSS.).
[Madagascar, 1880—forsan H. Nossibeanum C. Müller.]

Fam.: *Rhacopileæ.*

18. Rhacopilum Mauritianum (Hampe).
19. „ sp.

Fam.: *Neckereæ.*

20. Pterigynandrum fabronioïdes (C. Müller).

Fam.: *Meteorieæ.*

21. Lepyrodon Mauritianus (C. Müller).
22. Hildenbrandtiella nitens (Boswell MSS. nov. sp. 1887.)
23. „ puccinigera (C. Müller).
[There are, including nitens, but three described species of this circumscribed genus.]
24. Meteorium (Papillaria) cuspidiferum (C. Müller).
25. „ (Ærobryum) pseudocapense (C. Müller).
26. Porotrichum Robillardi (C. Müller).
27. „ sp. haud determ.

Fam.: *Stereodonteæ.*

28. Ectropothecium nanocristacastrensis (C. Müller).
29. „ sp. hand determ

Fam.: *Hypneæ.*

30. Jægerina solitaria (C. Müller). [= Hypnum solitarium (Brid.)]

* * * * *

General Meeting, February 21st, 1888.

Mr. CHARLES BAILEY, F.L.S., in the Chair.

Mr. ALFRED REÉ, Ph.D., F.C.S., of Middleton, near Manchester, and Mr. ALFRED D. HALL, of the Hulme Grammar School, Manchester, were elected ordinary members.

Ordinary Meeting, February 21st, 1888.

Mr. CHARLES BAILEY, F.L.S., in the Chair.

Mr. F. J. FARADAY, F.L.S., exhibited fragments of the perched blocks on Norber, a spur of Ingleborough, and other specimens of the rocks of the vicinity, and gave a preliminary sketch of a new hypothesis to account for the peculiar position of the perched blocks, with suggestions as to the influence of subsidence in the production of some of the remarkable features of the district, and the bearing of the hypothesis on the question of geological time.

On the change of incidence of Small-Pox at different ages during the years 1848-86. Part I. By R. F. Gwyther, M.A.

Received February 21st, 1888.

It may interest the Society to see to what extent the change of incidence of small-pox in regard to age, which was noticed by our late Secretary and Editor, has continued to act, and I offer to the Society some tables which I have prepared to illustrate the way in which that change has displayed itself. When I had nearly completed the preparation I found that the subject had been treated by the Registrar General in his report for 1880, and by the Medical Officer of the Local Government Board in his report for 1884, and each of these reports contains an extended examination of the causes acting. My reason for preparing these tables was, therefore, considerably weakened, and I should not have brought them forward except that the tables are fuller, and seem to indicate one or two points which I have not seen noticed. The tables which I have prepared give the death rates calculated for 1,000,000 living at the ages given at the top of each column. I have taken so large a number because, to many, whole numbers give a more intelligible picture than places of decimals.

I have kept the results for males and females separate, because there is a considerable difference between the incidence of small-pox on the two sexes at certain ages.

The subject of this paper is well illustrated by an excellent and interesting paper by Dr. J. C. Mc.Vail, read before the Philosophical Society of Glasgow, in 1882, "On the prevalence of small-pox in Kilmarnock in the 36 years, 1728–1764," in which he shows that epidemics occurred regularly at somewhat over 4 years; that the victims of each epidemic were almost entirely taken from those born since the preceding epidemic; that the rate calculated on this basis was a death rate of 126 per thousand; and that the deaths in the first four years were roughly in the rate of incidence shown by

0-	1-	2-	3-	4-
118	146	136	101	62

where the rates in successive years are progressively too low, because I have not allowed for diminution by deaths from other causes.

Comparing this with the corresponding columns of Table I., we see that the maximum infant death rate is now very decidedly within the first year, and probably within the first six months of life. As the epidemic of 1871–2 is unique in the years covered by the Registrar General's reports, I have considered it separately in Table II., and during that epidemic we see that the infantile death rate had begun to rise again in the fifth year, and we shall see later that the rise was more markedly continued during the next five years.

The decrease of death rate is well marked during the course of years that I am considering, except in the fourth year during the epidemic of 1871–2.

In the ages from 5–10 the diminution of death rate is well marked though less than the infantile rate, but during the epidemic of 1871–2, the increase of the death rate at this age was very considerable as is well shown by considering Table III.

After passing the age of ten, the reduction in death rate is not so considerable as to seem to require any special examination.

FEMALES.

I.—*Table showing the change of incidence of small-pox at different ages during the years 1848-1886, giving the death rate calculated for a population equally distributed over all ages.*

	0-	1-	2-	3-	4-	-5	5-	10-	15-	20-	25-	35-	45-	55-	65-75	All ages
1848-58						1279	291	81	95		67	36	21	13	13	239
1859-66	1551	700	659	549	391	819	179	78	100	115	84	60	35	32	16	180
1867-76	1239	529	469	451	466	646	295	136	185	233	186	126	69	56	40	226
1877-86	263	98	79	76	69	121	52	46	64	76	64	45	34	22	15	59

II.—*Table for comparison of incidence of small-pox at different ages during the years 1871-2 and the other years of the decade 1867-1876.*

1871-2	4357	1641	1566	1506	1740	2169	1150	528	723	839	697	458	285	212	125	835
Other years.	529	250	161	186	147	266	81	38	51	82	56	43	28	17	11	79

* *Table for comparison showing the change of incidence of zymotic diseases during the years 1848-1854 and the years 1880-1886.*

1848-54						2203	516	210	195		218	228	253	380	662	
1880-86						1435	226	73	67	95	110	92	53	77	162	

* This Table is inserted to show, to some slight extent, the general diminution of zymotic diseases during the period dealt with. It must, however, be remembered that the years 1849 and 1854 were bad cholera years.

MALES.

I.—*Table showing the change of incidence of small-pox at different ages during the years* 1848-1866, *giving the death rate calculated for a population equally distributed over all ages.*

	0-	1-	2-	3-	4-	-5	5-	10-	15-	20-	25-	35-	45-	55-	65-75	All ages
1848-58						1315	326	83	145		120	73	52	31	23	284
1859-66	1757	785	636	510	390	841	191	74	113	222	163	115	83	49	49	226
1867-76	1334	505	441	474	485	669	307	137	216	395	309	212	128	88	62	290
1877-86	269	99	87	84	76	125	63	42	63	108	106	83	61	37	30	79

II.—*Table for comparison of incidence of small-pox at different ages during the years* 1871-2 *and the other years of the decade* 1867-1876.

	0-	1-	2-	3-	4-	-5	5-	10-	15-	20-	25-	35-	45-	55-	65-75	All ages
1871-2	4401	1636	1413	1603	1846	2245	1276	519	787	1450	1115	793	516	300	214	1037
Other years.	566	225	198	188	146	274	92	42	73	133	109	66	47	33	23	102

* *Table for comparison showing the change of incidence of zymotic diseases during the years* 1848-1854 *and the years* 1880-1886.

	0-	1-	2-	3-	4-	-5	5-	10-	15-	20-	25-	35-	45-	55-	65-75	All ages
1848-54						2281	495	184	181		187	239	278	403	700	
1880-86						1478	206	51	59	66	63	62	58	108	201	

* This Table is inserted to show, to some slight extent, the general diminution of zymotic diseases during the period dealt with. It must, however, be remembered that the years 1849 and 1854 were bad cholera years.

III.—*Tables giving ratio of death rate at different ages to the death rate at all ages in different sets of years.*

MALES.

	-5	5-	10-	15-	20-	25-	35-	45-	55-	65-75
1848-58	4·6	1·1	·3	·5 (15-25)		·4	·3	·2	·1	·1
1859-66	3·7	·9	·3	·5	1·	·7	·5	·3	·2	·2
1867-76	2·3	1·	·4	·7	1·4	1·	·7	·4	·3	·2
1877-86	1·6	·7	·6	·8	1·3	1·3	1·	·8	·5	·4

FEMALES.

	-5	5-	10-	15-	20-	25-	35-	45-	55-	65-75
1848-58	5·4	1·2	·3	·4 (15-25)		·3	·1	·1	·05	·05
1859-66	4·5	1·	·4	·6	·6	·4	·3	·2	·2	·1
1867-76	2·9	1·3	·6	·8	1·	·8	·5	·3	·2	·2
1877-86	2·2	·9	·8	1·1	1·3	1·1	·8	·6	·4	·3

MALES.

	-5	5-	10-	15-	20-	25-	35-	45-	55-	65-75
1871-2	2·1	1·2	·5	·7	1·4	1·1	·7	·5	·3	·2
Rest of decade.	2·7	·9	·4	·7	1·3	1·	·6	·4	·3	·2

FEMALES.

	-5	5-	10-	15-	20-	25-	35-	45-	55-	65-75
1871-2	2·6	1·4	·6	·9	1·	·8	·5	·3	·2	·1
Rest of Decade.	3·3	1·	·5	·6	1	·7	·5	·4	·2	·1

IV.—*Comparative incidence of small-pox at different ages on the two sexes.*

	-5	5-	10-	15-	20-	25-	35-	45-	55-	65-75
1848-58	1·	1·1	1·	1·4 (15-25)		1·8	2·	2·5	2·4	1·7
1859-66	1·	1·	1·	1·1	2·	2·	1·9	2·4	1·5	3·
1867-76	1·	1·	1·	1·1	1·7	1·8	1·7	1·5	1·5	1·5
1877-86	1·	1·2	·9	1·	1·5	1·7	1·9	1·8	1·7	2·

In Table III. I have formed the proportion of the death rate from small-pox at the several ages to the death rate at all ages over the same period of time; we there see that, besides the maximum proportion at the ages under five (which has been diminished), there is a second maximum between the ages of 20 and 25. This appears from this table to have been increasing, but the increase is not more than would be accounted for by the diminution of the infantile rate.

If we pass beyond the age of 35 the increase of the death rate is obviously an actual increase.

To account for this it is in the first place obvious from such statistics as I have quoted from Dr. Mc.Vail's paper, that small-pox epidemics gave a considerable, if not complete, immunity to those who passed safely through one or two of them—a more lasting immunity than any that can reasonably be claimed from vaccination. If our record went further back we could gauge the effect of this most accurately. If this is, as seems to be the case, not an efficient reason to account for the rise of adult death rate from small-pox, and it is claimed that small-pox has increased in virulence (and there appear to be other than the statistical reasons for imagining this to be the case), the effect of this claim is to make the diminution in the death rate of early years more marked.

All the consequences of these hypotheses can only be truly estimated by the physician, and so I proceed with the discussion of the statistics.

In Table IV. I have calculated the ratio of the death rate of males to females at the several ages during the periods which I have been considering.

From this we see that up to the age of 20 the incidence upon the two sexes has been constant and practically identical. Beyond that age the disease has fallen considerably more heavily upon the males, the ratio being fairly constant, and somewhat less than 2, up to the age of 45. From 45–65 the discrepancy seems to be diminishing. The unsteadiness of the numbers between 65–75 is probably owing to the small number of actual deaths at those ages. The cause of this difference is not easily seen, but the effect appears very markedly at the age of 20 years, and continues fairly constant in later life.

Concluding this paper, which is merely descriptive, I may sum up the results to be—

1. That during the last 39 years, from some causes, the death rate of children from small-pox has been greatly diminished, the rate of diminution decreasing with age. (I.)

2. That above the age of 35 this diminution is actually changed into an increase of the death rate, in spite of the decreased death rate at all ages. (I.)

3. That, considering the death rate at all ages in comparison with the general death rate, the diminution in the proportionate rate does not continue beyond the tenth year, and above 20 years the proportionate death rate increases much more rapidly than the infantile rate decreases. (III.)

4. That during the severe epidemic of 1871-2, the proportionate death rate at higher ages was not far from normal, but that between the ages of 4 and 10 it rose to about $\frac{1}{3}$ more than the normal proportion, while among children under 4 the proportionate rate was considerably diminished. (III.)

5. That the incidence of small-pox on the two sexes seems to be identical up to the age of 20 years, and that after that age the death rate for males is about double that for females. (IV.)

A method of calculating the Electrostatic Capacity of a Conductor. By Henry Holden, B.Sc., Bishop Berkeley Fellow in Physics at the Owens College, Manchester. Communicated by Prof. Schuster, F.R.S.

(Received February 21st, 1888.)

The following paper contains a method for calculating the capacity of a conductor, the condition of the dielectrical medium being primarily considered. This method seems to be the most natural one, and affords a simple explanation of the meaning of the capacity of a conductor under any circumstances.

In works on electrostatics the capacity of a conductor in the presence of other conductors is generally defined as the quantity of electricity necessary to raise its potential by unity, all the other conductors being connected to earth. It is noted that this capacity does not depend on the nature or mass of the conductor, but on its external shape, and on the shape and position of the neighbouring conductors (not on their nature or mass), and that the nature of the dielectric between the conductors also affects the capacity of the conductor considered. Thus it is evident that the so-called capacity of a conductor is not one of its true physical properties, and we may infer that a conductor has really only an indirect influence in determining the value of what is known as its capacity[1].

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[1] The first problem in calculating capacity usually considered in books on Electrostatics is the case of a charged sphere at an infinite distance from any other conductor. The capacity of such a charged sphere is generally calculated somewhat as follows. It is first assumed that only the quantity of electricity on the sphere need be considered since all other quantities of electricity are, by hypothesis, infinitely distant. A previously-found expression for the potential at a point is then used to prove that the potential at the centre of (and therefore throughout) the sphere is $V=\frac{Q}{R}$ where V is the increase of potential at the centre of the sphere of radius R due to a quantity Q of electricity on the surface of the sphere. Substituting for Q its value CV (where C is the capacity of the body) it follows that $C=R$. We are afterwards told that if the medium surrounding the sphere be not air, the capacity is equal to KR where K is the

It is known that specific inductive capacity bears the same relation to flow of force[2] as conductivity does to a flow of electricity[3]. Consider, therefore, the problem in current electricity corresponding to the above electrostatical one. An anode A is placed in a conducting medium in which are placed several kathodes B, C, etc. Then in the phraseology generally used for capacity, the conductivity of the anode A would be spoken of, and it would be said that the conductivity of A depended neither on the nature nor the mass of A, B, C, etc., but only on their external shape and their relative positions. Finally it would be said that if the medium between A, B, C, etc., was not a certain one, the result obtained by calculation from this method of considering the phenomena would have to be multiplied by a certain number, fixed for the medium in question. Such a mode of viewing the facts is evidently irrational, and tends to withdraw the attention from the real principle, namely, that the conductivity under consideration is that of the medium, and that the function of the electrodes is simply to bound the portion of the medium which is traversed by the current. Adapting this mode of description to electrical capacity, *the so-called capacity of the conductor is the capacity of that portion of the dielectric bounded by the conductors and traversed by the lines of*

specific inductive capacity of the medium, but it is not easy to see, from the above assumptions, why this should be, or in other words, if only the quantity of electricity on the suface of the sphere need be considered, why the potential at the centre of the sphere due to a quantity of electricity on its surface should depend on the nature of the medium outside the sphere. The advantage of the method now advocated is that the medium between the charged body and the corresponding induced charge is always kept in view.

[2] Flow of force along an air tube of force $= F dS$ where dS is the perpendicular section of the tube and F the mean value of the force on that section.
$= 4\pi dq$ where dq is the quantity of electricity at the commencement of the tube.

[3] We have $Q = C(V_1 - V_2)$
or $4\pi Q = 4\pi C(V_1 - V_2)$
or Flow of force $= 4\pi C \times$ diff. of pot.

force. I shall show later how it may be calculated on this supposition. Taking this view of the matter, it is evident why the so-called capacity of a conductor is not altered by any changes in the conductor (such as change of material, or change from a solid to a hollow conductor) which do not alter the direction and extent of the lines of force.

The capacity of a certain portion of a dielectric, bounded by lines of force and equipotential surfaces, may be therefore defined as the *quantity of electricity*[1] *which has to be distributed over one end* (*an equal but opposite quantity being on the other end*), *in order to cause unit difference of potential between the two ends*, and we may call the capacity of a portion of a dielectrical medium of unit length and unit section the specific capacity of that dielectric; a term corresponding to specific conductivity in the case of a conducting medium. Each dielectric will have its own specific capacity, and the ratio of this to that of air will, of course, be the specific inductive capacity of the dielectric considered.

Method of calculating capacity.

Consider a charged conductor A at potential V_A in the presence of other conductors B, C, etc., at potentials V_B, V_C, etc., and suppose that the dielectric medium between has a specific inductive capacity $= K$.

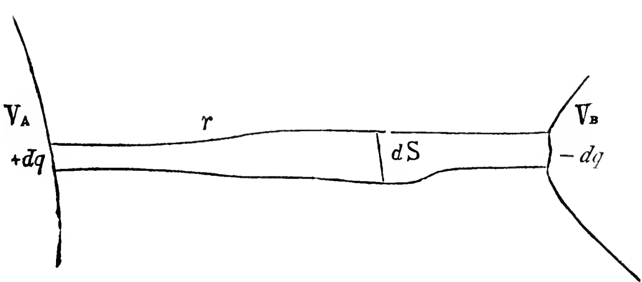

Fig. 1.

[1] The distribution of the electricity is supposed to be such that the lines of force proceeding from one quantity of electricity to the other bound the portion of the dielectric under consideration.

Consider an elementary tube of force proceeding from the elementary quantity of electricity dq on A: this tube will evidently end on another conductor, B, and enclose there a quantity of electricity $= -dq$. Let dS be the area of a perpendicular section of this tube, at a distance $= r$, measured along the tube, from any convenient point. Then if F is the value of the force at dS we have, by the theorem of the flow of force,

$$F\,dS = \frac{4\pi dq}{K},$$

$$\text{or} \quad -\frac{dV}{dr} = \frac{4\pi dq}{K\,dS},$$

$$\text{or} \quad \frac{-dV.K}{4\pi dq} = \frac{dr}{dS},$$

or, integrating along the tube of force, from A to B, we have, since dq and K are constant along this tube,

$$\frac{K}{4\pi dq}\int_{V_1}^{V_2}(-dV) = \int\frac{dr}{dS}$$

$$\frac{K.(V_1 - V_2)}{4\pi dq} = \int\frac{dr}{dS}$$

$$\therefore \quad \frac{4\pi dq}{K(V_1 - V_2)} = \frac{1}{\int\frac{dr}{dS}}$$

or if the whole quantity of electricity on A which is at the base of the tubes of force proceeding to B is q, we get, since $(V_1 - V_2)$ is constant for these tubes of force,

$$\frac{4\pi q}{K(V_1 - V_2)} = \int\frac{1}{\int\frac{dr}{dS}}$$

where $\dfrac{dr}{dS}$ has to be integrated along a tube of force between limits of r given by the surfaces of A and B, and then the reciprocal of this integral has to be integrated so as to include all the tubes of force proceeding from A to B. Again, $\dfrac{q}{V_1 - V_2}$ is the capacity of that portion of the dielectric enclosed by the tubes of force proceeding from A to B = C_{AB}, say and ∴

$$\frac{4\pi . C_{AB}}{K} = \int \frac{1}{\int \frac{dr}{dS}}.$$

We should get similar expressions for the portion of the dielectric enclosed by the tubes of force proceeding from A to the other bodies, so that summing up so as to include all the dielectric through which the lines of force from A pass,

$$\Sigma \frac{4\pi C}{K} = \Sigma \int \frac{1}{\int \frac{dr}{dS}}$$

The following examples will show the applicability of the method.

Ex. 1. Concentric spheres, radii R_1 and R_2. The lines of force are radii, and $dS = r^2 d\omega$; the limits of r being R_1 and R_2

$$\int_{R_1}^{R_2} \frac{dr}{dS} = \int_{R_1}^{R_2} \frac{dr}{r^2 d\omega} = \frac{1}{d\omega}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

The inverse of this has now to be integrated so as to include all the tubes of force proceeding between the two spheres; the limits of $d\omega$ are ∴ o and 4π, or

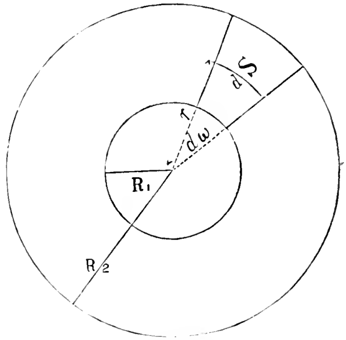

Fig. 2.

$$\text{or } \int \frac{1}{\int \frac{dr}{dS}} = \int_0^{4\pi} d\omega . \frac{R_1 R_2}{R_2 - R_1} = 4\pi \frac{R_1 R_2}{R_2 - R_1}$$

$$\therefore \frac{4\pi C}{K} = 4\pi \frac{R_1 R_2}{R_2 - R_1}$$

$$\text{or } C = \frac{K R_1 R_2}{R_2 - R_1}.$$

Ex. 2.—Parallel planes, surface S, at distance *e*.

Assuming the lines of force to be parallel, the section of the tube of force is evidently independent of r or

$$\int_0^e \frac{dr}{dS} = \frac{e}{dS} \text{ and } \int_0^S \frac{1}{\int \frac{dr}{dS}} = \int_0^S \frac{dS}{e} = \frac{S}{e}$$

$$\therefore \quad \frac{4\pi C}{K} = \frac{S}{e}$$

$$\text{or} \quad C = \frac{KS}{4\pi e}$$

From this example it is seen that the specific capacity of a dielectric (as defined above, namely, the capacity of a unit cube) is equal to $\frac{K}{4\pi}$, and that the capacity of a portion of a dielectric is got by multiplying the specific capacity by the cross section, and dividing by the length of the dielectric, assuming that the cross section of the portion of the dielectric considered remains uniform. If it does not, we must have recourse to a process of integration, as shown above.

Ex. 3.—Coaxal cylinders, of length l, and radii R_1 and R_2.

In this case, the lines of force are evidently radii between the two cylinders. Considering a tube of force formed by two planes passing through the axis, we have

$$dS = l \,.\, rd\theta$$

$$\therefore \int_{R_1}^{R_2} \frac{dr}{dS} = \frac{1}{ld\theta} \log \frac{R_2}{R_1}$$

The limits of θ are evidently 0 and 2π.

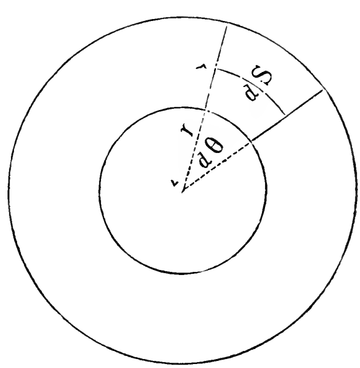

Fig. 3.

$$\therefore \int \frac{1}{\int \frac{dr}{dS}} = \int_0^{2\pi} \frac{l d\theta}{\log \frac{R_2}{R_1}} = \frac{2\pi l}{\log \frac{R_2}{R_1}}$$

$$\therefore \frac{4\pi C}{K} = \frac{2\pi l}{\log \frac{R_2}{R_1}}$$

$$\text{or } C = \frac{K \, . \, l}{2 \log \frac{R_2}{R_1}}.$$

Ex. 4.—Cylinders of circular section, one inside the other but not coaxal.

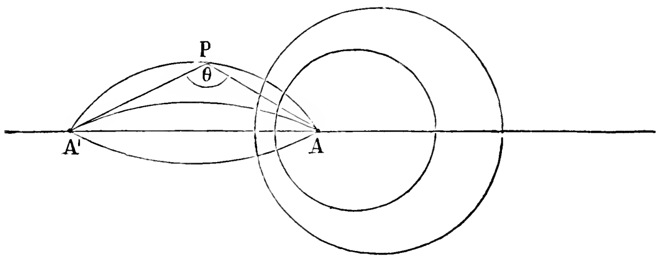

Fig. 4.

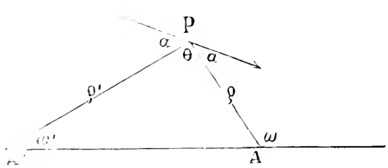

Fig. 5.

Let A and A′ be conjugate points with respect to the circular sections of each of the cylinders. Then, it is known that the lines of force between the cylinders are arcs of circles passing through A and A′, each line of force being therefore defined by the condition $\theta =$ constant (see *Fig.* 4). Let P be a point on a line of force, and suppose that the direction of the force at that point makes angles α and α' with AP($=\rho$) and A′P($=\rho'$) respectively. Then since dr is measured in the direction of the force, and dS perpendicular to it, we have (see *Fig.* 5)

$$dr\cos\alpha = d\rho \qquad dr\cos\alpha' = d\rho'$$

$$dS\cos\alpha = l\rho d\omega \qquad dS\cos\alpha' = l\rho' d\omega' \text{ if } l \text{ is length of cylinders.}$$

$$\therefore \frac{dr}{dS} = \frac{d\rho}{l\rho d\omega} = \frac{d\rho'}{l\rho' d\omega'}$$

$$\therefore \frac{dr}{dS}(d\omega - d\omega') = \frac{1}{l}\left(\frac{d\rho}{\rho} - \frac{d\rho'}{\rho'}\right)$$

But (see Fig. 5)

$$\omega - \omega' = \theta$$

$$\text{and } \therefore d\omega - d\omega' = d\theta$$

$$\therefore \frac{dr}{dS} = \frac{1}{ld\theta}\left(\frac{d\rho}{\rho} - \frac{d\rho'}{\rho'}\right)$$

Integrating along a line of force, θ being therefore constant: and denoting limits of ρ and ρ' corresponding to the two cylinders by the suffixes 1 and 2

$$\int \frac{dr}{dS} = \frac{1}{ld\theta}\left(\log\frac{\rho_2}{\rho_1} - \log\frac{\rho'_2}{\rho'_1}\right)$$

$$= \frac{1}{ld\theta}\log\frac{\rho_2}{\rho'_2} \cdot \frac{\rho'_1}{\rho_1}.$$

But if R_1 and R_2 are the radii of the two cylinders, and D_1 and D_2 the distances of A′ from their centres

$$\frac{\rho_2}{\rho'_2} = \frac{R_2}{D_2} \qquad \frac{\rho_1}{\rho'_1} = \frac{R_1}{D_1}$$

by the properties of conjugate points

and $$\therefore \int \frac{dr}{dS} = \frac{1}{ld\theta}\log\frac{R_2}{D_2} \cdot \frac{D_1}{R_1}.$$

The coefficient of θ being thus independent of θ, it is easy to perform the second integration.

$$\int \frac{1}{\int \frac{dr}{dS}} = \int \frac{ld\theta}{\log\frac{R_2}{D_2} \cdot \frac{D_1}{R_1}} = \frac{2\pi l}{\log\frac{R_2}{D_2} \cdot \frac{D_1}{R_1}},$$

since limits of θ are o and 2π

$$\therefore \text{ by formula } \frac{4\pi C}{K} = \frac{2\pi l}{\log\frac{R_2}{D_2} \cdot \frac{D_1}{R_1}}.$$

$$\therefore\ C = \frac{Kl}{2\log\frac{R_2}{D_2} \cdot \frac{D_1}{R_1}}.$$

If the cylinders are coaxal, the external conjugate point is at an infinite distance, or

$$D_1 = \infty = D_2,$$

and the usual expression for the capacity of co-axal cylinders results.

If the external cylinder becomes a plane, at a finite distance from the other cylinder, its centre is at an infinite distance, or

$$R_2 = \infty = D_2,$$

$$\text{and } \therefore\ C = \frac{Kl}{2\log\frac{D_1}{R_1}}.$$

If the distance between the centres of the cylinders and their radii are given, D_1 and D_2 may be easily expressed in terms of these quantities.

Thus, it is seen that this method is easily applicable to all the ordinary problems in capacity; with more complicated cases difficulties arise in effecting the requisite integrations, as must necessarily be the case whatever method is adopted.

Ordinary Meeting, March 6th, 1888.

Professor W. C. WILLIAMSON, LL.D., F.R.S., Vice-President, in the Chair.

Mr. J. R. H. WILLIAMSON exhibited an 800-candle power Edison-Swan incandescent lamp, requiring about 18 to 20 ampères of current at an electro-motive force of 112 volts or 2½ watts per candle. Mr. Williamson explained the advantages offered by these high candle-power lamps over the "arc" lamps. He also exhibited a new form of American frictional electrical machine for exploding dynamite in blasting, and capable of exploding 1,000 fuses at once.

On the change of incidence of Small-Pox at different ages. Part II. By R. F. Gwyther, M.A.

(Received March 6th, 1888.)

In communicating to the last meeting the tables showing the change of incidence of death by small-pox at different ages, I said that the change might possibly not be altogether accounted for by our changed sanitary and other arrangements. If this is the case, the question would only be partly a question of statistics, and it appears desirable to consider whether we could attribute the change entirely to our changed condition without having recourse to an assumed increase of the virulence of small-pox. In a paper, of which I shall make a large use, I find that in 1760 it was held as a medical opinion that small-pox became more fatal beyond the age of 20 years. This strengthened my own opinion, that the change of incidence is normal, and in this note it is intended to collect some evidence on that point, leaving the medical question for competent authorities.

In the first place I am going to compare the death rates of vaccinated and unvaccinated up to the age of 20, which I think we may take as beyond the extreme limit of protection by infantile vaccination. I am aware that such statistics are to some extent untrustworthy, but I am not going to make my argument depend on the actual numbers so much as on the general character of the series which the numbers show. In the Report of the Medical Officer of the Local Government Board for 1886, there are tables showing the deaths from small-pox in London during the years 1884 and 1885, of inhabitants born in London. Since 1872 the proportion of the inhabitants of London not finally accounted for in the vaccination returns has varied from 5·7 per cent to 9·3, and it appears that we shall not be far wrong in assuming that 1 in 12 in London escaped vaccination.

Deaths from Small-Pox of Metropolitan Inhabitants born in the district.

VACCINATED.

Ages.	0-1	1-5	5-10	10-15	15-20	20-30	30-40	40-50	50-60
1884.	5	7	5	5	14	14	13	3	1
1885.	7	10	6	11	23	23	22	1	1

UNVACCINATED.

Ages.	0-1	1-5	5-10	10-15	15-20	20-30	30-40	40-50	50-60
1884.	89	57	20	12	7	3	2	2	1
1885.	128	78	51	19	7	13	1	0	0

Looking at the progression of these numbers of the unvaccinated, one is distinctly reminded of the course of the death rate at different ages at the time when previous attacks by small-pox conferred the only immunity from future attacks. And if the death rate on the vaccinated community taken in the proportion of about 11 to 1 had been at the same rate, up to the age of 20, the death rate at the ages beyond, even if we do not lower it on the plea of immunity conferred by small-pox, would not appear unreasonably large.

Since 1880 the Registrar General's Returns have separated the deaths from small-pox under the heads Vaccinated, Unvaccinated, and No Statement, and these returns show the same kind of progression as I have illustrated by the table above, and I know no reason why these should not be taken as representing the general features of the incidence of small-pox on the vaccinated and unvaccinated when equally exposed to it as during the said years in London.

It seems desirable to apply some amount of calculation to make the comparison more obvious, and to that I now proceed.

My attention was called by Dr. Bottomley to a Memoir by Daniel Bernoulli among the Mémoires de l'Académie Royale des Sciences for the year 1760, entitled "Essai d'une nouvelle analyse de la mortalité causée par la petite Vérole," &c., which is very interesting both on account of the attempt to find a mathematical expression for the death rate from small-pox, and as giving a good idea of the virulence of the disease and its incidence at different ages at that date. As it may interest members of the Society, and will certainly illustrate the change of the incidence of the disease between that date and this, I ask leave to add this note to my paper lately read.

Two short passages I will quote at length :—

"J'ai dit d'abord que la petite vérole naturelle enlève la huitième ou la septième partie de ceux qui en sont malades.

En Angleterre, on adopte assez communément la dernière proportion : dans d'autres pays il ne paraît pas que la mortalité de cette maladie soit si grande.

"Quant à la proportion qu'il y a de la mortalité de la petite vérole à la mortalité entière du genre humain, on a supposé communément en Angleterre comme 1 à 14 : il y a là-dessus des listes rapportées par M. Susmilch, qui marquent qu'à Londres il est mort de la petite vérole 19,745 sur 260,875, ce qui donne la proportion 1 à $13^1/_5$; à Vienne, cette maladie a enlevé 1,083 sur 13,521, c'est 1 sur 12½; à Berlin, 586 sur 6771, c'est 1 sur 11½; à Breslau, 431 sur 4,579, c'est 1 sur 10½. Mais ces dernières proportions n'ont été prises que pour deux et trois ans pendant lesquels il peut y avoir eu une épidémie un peu forte."

I am unable to state what is now regarded as the average ratio of deaths to cases, but during the last ten years the ratio of deaths from small-pox to the total deaths has been about 1 to 286, and during the epidemic "un peu forte" of 1871-2 the ratio was about 1 to 23½.

It is necessary to note this change to understand at all how it was possible that his mathematical results which I am about to notice could have seemed to represent in any respect the rate of mortality at the time. It must be borne in mind that the mortality tables which they had were very defective; but the objections to the paper seem to have been founded on minor points, and not on any doubt of its general representation of the facts of the case, while at the present time the divergence of his results from actual experience would be patent to everyone. The investigations of which I speak are two, which I shall give in only slightly modified form :—

1. To find the ratio between the number of those at an age x who have not yet had small-pox, and the total number of survivors at that age.

Let the age be expressed by x, the number of survivors at that age by ξ, the number of these survivors who have not had small-pox by s: suppose that during the unit of time in which x is measured, on the average out of n persons one takes small-pox, and that out of m persons who take small-pox on the average one dies, and let us suppose that m and n are constants at different ages.

Then the number of those who take small-pox during the time dx is $\frac{s\delta x}{n}$, and the number for whom it ends fatally is $\frac{s\delta x}{mn}$. Consequently those who die from causes other than small-pox is $-d\xi - \frac{s\delta x}{mn}$. Taking the proportion of these deaths which correspond to the number s who have not had small-pox, we get

$$-\frac{s\delta\xi}{\xi} - \frac{s^2dx}{mn\xi}.$$

Then $-ds$ denoting evidently the number who take small-pox and do not die, during the time dx, we have the equation

$$-ds = \frac{s\delta x}{n} - \frac{sd\xi}{\xi} - \frac{s^2dx}{mn\xi}.$$

Although this equation contains three variables, s and ξ only appear in the form of the ratio $s:\xi = q$ and we get

$$\frac{mndq}{mq - 1} = dx$$

$$q = \frac{m}{\epsilon^{\frac{x+c}{n}} + 1}.$$

And we can determine the constant by supposing that at birth $s = \xi$, $q = 1$, hence

$$s = \frac{m}{(m-1)\epsilon^{\frac{x}{n}} + 1}\xi.$$

From this relation Bernoulli easily forms theoretical tables which it appears that he thought fairly represented the small-pox mortality at the time. Putting m and n each equal to 8, he considers that his tables give good results.

The rate of death from small-pox calculated from it he thinks relatively too high for children under one year, and proposes to account for it as a difference rather moral than physical and attributes it to the slight communication which such children have with the outside world. As the difference would relatively now seem to be in the other direction, we may have to consider a change of manners as partially accounting for it. To return, it is obvious from the method of obtaining the equation above that it would only be true even approximately for a disease in an endemic and not an epidemic form, and therefore if we are going to lay any weight on Halley's Tables, with which Bernoulli compares his formula, it must be on the hypothesis that, although in places small-pox might be epidemic, the general character of its incidence upon the peoples from whose death rate the tables were founded was, on the average, that of an endemic disease. The results drawn from it would neither agree with modern tables nor yet with such tables as those given by Dr. McVail in the paper quoted above, though they would agree with the latter in limiting the excessive incidence of small-pox to youth.

Comparing the death rates in the first and the second years as found from this formula, they appear to be in the ratio of 13·1 to 12·4, and, as I stated before, Bernoulli is forced to consider the first too high. It is so certainly if we may compare it with the Kilmarnock death rate; but at present the ratio in England appears to be about 3 : 1, and the heaviest death rate appears to be compressed into the first half-year of life, during part of which children are in no way protected. Considering further the death rate from small-pox during the first five years of life, Bernoulli concludes that he is not far wrong in considering it about one-tenth of the total death rate during those years. A similar comparison during the years 1871-2 gives us about one-thirtieth, which is certainly very heavy; but on the average of the last twenty years we find it is a very small fraction.

Passing to the other limit to which Bernoulli thinks that his theory applies, we find that out of 1,000 living at the end of the first year of life there would be 32 only at the age of 24 who had not already had the small-pox, and even without allowing for deaths by other diseases, only one on an average at the age of 49. On account of the smallness of these numbers Bernoulli does not attempt to alter his theory to deal with them, but limits its application to about 20 years. In the then state of affairs the argument of the small number treated of was a sufficient reason for this neglect ; but for us it is the reason for supposing that the theory could not be pressed further that is most important. I quote it : "Ce n'est qu'au-dessus de cet âge qu'on suppose ordinairement la petite vérole commencer à devenir un peu plus dangereuse."

As far as I am able to judge from non-professional literature on the subject, as for instance Mr. Baxendell's paper before this Society, later writers on the subject have been accustomed to speak of small-pox in past times as having been fatal mainly in youth, and not to have been a disease greatly incident on manhood and age. As far as the paper considered is evidence, the facts were different. Small-pox appears to have been considered more fatal with advancing years, and the death rate at those ages was only kept low by the immunity conferred by previous attacks of small-pox.

We must consider to what extent the paper of a mathematician can be considered evidence on this point. It seems to depend on the position and eminence of the writer, who could not afford to be convicted of false representation in his paper, on the general character of his scientific writings, on the means he was likely to have to obtain the recognised views of the medical profession, and on the fact that, as far as one can gather from the introduction written five years later than the paper, the paper was not attacked on the score of not representing the actual facts of the case.

Passing on to Bernoulli's second investigation—

Theorem II.—To find the ratio of the number of those who would be alive at any age, if death from small-pox was prevented, other circumstances remaining the same, to the number who would be alive on the hypothesis of the previous theorem.

The other letters retaining their original significations, let ζ denote the numbers living at the age x under the changed circumstances.

The total mortality during the time dx will now be

$$-\zeta\left(d\xi+\frac{s\,\partial x}{mn}\right)/\xi,$$

which we must write $-d\zeta$.

$$\therefore\ \frac{d\zeta}{\zeta}-\frac{d\xi}{\xi}=\frac{s\,\partial x}{mn\xi},$$

substituting for s/ξ and integrating we get

$$\zeta=\frac{m\epsilon^{\frac{x}{n}}}{(m-1)\epsilon^{\frac{x}{n}}+1}\xi,$$

and thus the required ratio has been found.

Now Bernoulli's object was to show to what extent life would be saved by adopting the system of inoculation, but we may apply his results to the consideration of other circumstances not foreseen by the author. Take the two most extreme cases to make a comparison. Imagine a locality in which small-pox is epidemic for x years, and that, in another locality having the same number of inhabitants, from superior sanitary or other reasons small-pox does not appear for x years, but that the inhabitants have no immunity against small-pox in case it should be introduced, we see from what I have proved above that the ratio between the numbers subject to small-pox in the two places would be

$$\epsilon^{\frac{x}{n}} : 1.$$

To take an instance, making use of the numbers which Bernoulli found to suit the case fairly in 1760, and taking $x = 24$. Out of 1,000 who were living at the end of one year there would be 32 subject to small-pox at that age in the one case, and about 650 similarly subject to it in the protected locality, and, therefore, if small-pox attacked the latter locality they might expect for a time a death rate at the age of 24 about twenty times as great as the death rate at a corresponding age in the locality where small-pox was epidemic. In addition to this we should take into consideration the more fatal character of the disease when incident on adults, as in the latter case compared with the former case, where nearly all would have suffered from it in infancy.

It must be borne in mind that no weight is laid on these numbers, which afford merely an illustration founded upon ratios found to be approximately suitable in 1760, but the considerations involved in it may aid us in understanding how the change in incidence of small-pox during the last 39 years shown in my tables may have originated.

In the first place, unless other evidence of an increased virulence in the nature of the disease is forthcoming, we may lay that hypothesis on one side, as not being necessary to explain the peculiarities shown in the tables, while an increasing fatality with advancing years may be a normal feature in the disease.

Secondly, I shall take it for granted that vaccination in infancy does not confer an immunity which extends beyond adolescence, and consequently that beyond that age the only safeguard which is general in England against epidemics of small-pox is our improved sanitary condition, which is again modified by the increasing density of population. Judging by the general statistics of disease, we have no reason to believe that our sanitary system is on the high road to extinguish any one of our epidemic diseases. We may, therefore, consider that, as far as adults are considered, the extent to which they are now liable to attacks of small-pox during an epidemic is approximately expressed by the formula of Bernoulli's first theorem, in which x is now to stand for the number of years during which they have been exposed to small-pox in an epidemic form. If, for instance, a person aged 35 now has passed through a smaller number of years of epidemic than a person aged 35 forty years ago, we may reasonably suppose that his chance of taking small-pox is greater, and that the ratio may be expressed in some way similar to that of Theorem I. As far as infantile small-pox is concerned the law of incidence is altered altogether, and I do not know where we are to look for the cause except in our system of vaccination. Much light might be thrown on this subject by a comparison with the similar statistics of the German Empire, if their present system of vaccination has been carried on long enough to give comparable results, and this, I think, must be the case, as it is during the action of the cause that we can but estimate its effect.

If, as I have assumed, vaccination has only a protective influence for a limited time, and if its effect is to reduce the number of small-pox cases up to adolescence and then lose its virtue, its secondary effect must be to leave a larger number subject to small-pox at adult ages, according to Theorem II. And that this effect is operating would seem to be the evidence given by my tables. On this point we may see Bernoulli's answer to certain doctors who objected that inoculation might form a continuous source of infection, each case communicating the infection to ten others, and these again in the same ratio, thus quickly arriving at a number exceeding the total population of the world. The objection in this form was absurd, but Bernoulli's answer was that perhaps it might be better for the human race if the malady was in this way endemic, and that possibly the return of an epidemic long delayed might commit more terrible ravages in one year than the uniform endemic disease in a long series of years. This appears to be just the position to which we have arrived, and it is sufficiently grave to demand that all the possible causes should be considered without prejudice or partiality. It is for this reason that I have put forward the argument that, owing to the imperfection of our sanitary and other arrangements, they may carry a certain amount of danger past the age which Bernoulli called the date of civil birth, when a person becomes a useful member of society, and that as the increasing death rate from small-pox at adult ages may be the normal consequence of our sanitary position, it becomes necessary to examine that position more closely, and to discover in what way it may be improved. One of the first steps to be taken in the matter ought to be an exhaustive analysis of the action of repeated vaccination now carried out for some years on the death rate in the German empire; as on this point we have statistics of which one feels the want in investigating the action of inoculation and the earliest effects of vaccination.

For instance, when it is claimed, as it was by Mr. Baxendell, that vaccination does not now afford the protection which it did for many years after its general adoption, the obvious answer is that adults were made immune by previous epidemics, and that this acted alongside of vaccination; whereas now, a vast section of the population have no safeguard other than vaccination. But to weigh this argument we have only the statement from the yearly Bills of Mortality, delivered by Dr. Lettsom to a Committee of the House of Commons in 1802, and its continuation in the Report of the Medical Officer in 1881, which do not show the incidence at different ages. I here wish to maintain that the rise which has been noted in the death rate finds sufficient reason to account for it in the reduction of the general distribution of small-pox. And that, therefore, we must use better sanitary means for dealing with it. The means seem to be three :—

1. Better methods of protecting the individual.
2. Better methods of preventing the spread of an epidemic.
3. Better methods of preventing the rise of an epidemic.

With regard to the latter of these methods, careful search ought to be made to find out whether small-pox is endemic in any localities; this may possibly be the case without any great small-pox mortality, as it is quite conceivable, and not indeed unlikely, that small-pox is not very fatal when the circumstances which favour an epidemic are not present: nor is it necessary that in case of an epidemic it should be most fatal in the locality where it has been endemic.

Especially does London deserve a complete examination of this kind, as its death rate from small-pox now maintains itself at sixfold that of the rest of England, as is shown in this table, taken from the Report of the Medical Officer for 1884.

Years......	1847-49	1850-54	1855-59	1860-64	1865-69	1870-74	1875-79	1880-84
London ...	460	300	237	281	276	654	292	244
Provinces.	274	271	192	175	122	389	48	34

The special circumstances of London seem from this table to have been very favourable to small-pox, as they show no decline comparable with that of the rest of England. In 1886 there was a complete change, there were only 5 deaths in London returned as from small-pox,—1 between 20 and 25, 2 between 25 and 35, and 2 between 35 and 45. Nor during the previous term of years was the epidemic without intervals. It is during these periods of quiescence that the most effective measures against the epidemic rise of small-pox can be taken, when probably the history of each case could be learnt, and the existence of endemic centres of small-pox, possibly not in a malignant form, could be discovered, and perhaps the circumstances which allow of its existence disclosed. The epidemic of 1871-2 was European in its dimensions, and could not be so easily guarded against, but most of our epidemics are more local, and seem to indicate that some epidemic cause has allowed an existing disease to become malignant.

MICROSCOPICAL AND NATURAL HISTORY SECTION.

Ordinary Meeting, March 12th, 1888.

The President, Professor W. C. WILLIAMSON, F.R.S., in the Chair.

Mr. J. J. ASHWORTH was elected a member of the section.

Mr. THOS. ROGERS showed specimens of a small beetle, *Niptus hololeucus*, which had appeared in large numbers in some dried peppermint.

Mr. H. HYDE exhibited a set of plants, collected by Mr. Charles West in Portugal.

Mr. JOHN BOYD exhibited by means of the Lantern two sets of drawings. One illustrating the various changes which occur in the development of *Argulus*, the other showing both sexes of *Anchorella uncinata*.

Mr. E. PYEMONT COLLETT exhibited a small type collection of British Heminoptera-Heteroptera.

The PRESIDENT showed, under the microscopes, the reproductive gemmules on the roots of mosses, described at the previous meeting.

Ordinary Meeting, March 20th, 1888.

Professor OSBORNE REYNOLDS, M.A., LL.D., F.R.S., in the Chair.

Mr. PICKSTONE, introduced by Mr. W. H. JOHNSON, B.Sc., exhibited and explained the working of a portable pneumatic tool of remarkable power, giving 5,000 to 20,000 strokes per minute, and also a small steam compressed-air engine working at 5,000 revolutions per minute. Mr. Pickstone explained that one of the peculiarities of these inventions was that the piston worked without packing other than the air by which it was cushioned, and he dwelt upon the various uses to which the principle of the inventions might be applied.

Ordinary Meeting, April 3rd, 1888.

Mr. R. F. GWYTHER, M.A., in the Chair.

Mr. ALFRED BROTHERS, F.R.A.S., communicated a paper entitled, "Note on a Nickel Arsenide," by H. E. BROTHERS, A.I.C., F.C.S. Mr. Brothers said:—In a paper "On the formation of some metallic Arsenides," (*Comptes Rendus*, Vol. 86) M. Descamps describes the production of a new Arsenide of Nickel (Ni_3As or, Ni_6As_2) by fusing the arsenate first with potassium cyanide and then in boric acid, and also directly by heating nickel oxide at a high temperature with the cyanide in presence of an excess of metallic arsenic. Knowing nothing further of this compound, its formation under different circumstances, and in larger quantities, appears interesting.

In the rebuilding of a flue to a furnace in which arsenical nickel-cobalt ores had been smelted, numerous globules of a metal were found intermingled with half-fused brick. An analysis gave :—

	Found.		Calculated for Ni_3As.
Nickel	67·73%	70·42%	70·2%
Co.	1·26 ,,		
Cu.	1·20 ,,		
Fe.	0·23 ,,		
Arsenic	28·14 ,,	28·59%	29·8%
S.	0·45 ,,		
	99·01%		

The pieces were dull on the surface, due probably to oxidation with a corresponding loss of arsenic.

A specific gravity determination at 20° C. gave 8·668.

Each globule seems to have contracted considerably on cooling, and has a crystalline structure. Having been left in a damp atmosphere, there formed on the surface small green particles which were insoluble in water but soluble in acids and ammonia. This, I thought, might be the green arsenate formed by direct oxidation, but in the few milligrammes obtained after several months exposure I did not succeed in detecting arsenic.

As to its origin, the ore which had been smelted, and the metal it yielded, contained cobalt and nickel in the proportion of one to two. I cannot discover that anything similar has before been noticed after working ores containing much nickel, but it is certain that nothing has ever passed over to the flues from cobalt ores, and this might be inferred from the different behaviour of the two metals in the present case.

MATHEMATICAL AND PHYSICAL SECTION.

Annual Meeting, March 14th, 1888.

WM. THOMSON, F.R.S.Ed., F.C.S., F.I.C., Vice-President of the Section, in the Chair.

The Treasurer's accounts for the year 1887–8 were presented.

TREASURER'S ACCOUNT.

	£	s.	d.
Balance from last year	6	15	0
Cash received during present year...	2	11	11
	9	6	11
Payments during present year ...	4	4	7
Balance in favour of Section... ...	£5	2	4

On the motion of Mr. J. A. Bennion, seconded by Mr. J. Angell, it was resolved :—"That the Treasurer's accounts be received and passed."

The following is a list of the members and associates of the Section :—

Members:

JOHN ANGELL, F.C.S., F.I.C.
ALFRED BROTHERS, F.R.A.S.
JAMES BOTTOMLEY, D.Sc., B.A., F.C.S.
F. J. FARADAY, F.L.S., F.S.S.
S. OKELL, F.R.A.S.
J. P. JOULE, LL.D., D.C.L., F.R.S.
WM. THOMSON, F.R.S.Ed., F.C.S., F.I.C.

Associate:

J. A. BENNION, M.A., F.R.A.S.

The following gentlemen were then elected Officers of the Section for the ensuing year:—

President:
J. P. JOULE, LL.D., D.C.L., F.R.S.

Vice-Presidents:
W. THOMSON, F.R.S.ED., F.C.S., F.I.C.
J. A. BENNION, M.A., BARRISTER-AT-LAW.

Treasurer:
JAMES BOTTOMLEY, D.SC. B.A., F.C.S.

Secretary:
JOHN ANGELL, F.C.S., F.I.C.

Dr. BOTTOMLEY made some remarks on a paper by Spring and Van Aubel in the October number of the *Annales de Chimie et Physique*, on the rate of solution of zinc in hydrochloric, hydrobromic, and hydriodic acids.

Mr. WM. THOMSON made some remarks on the subject of the expansion of card and other similar substances under varying conditions of dryness.

MATHEMATICAL AND PHYSICAL SECTION.

Ordinary Meeting, April 11th, 1888.

WM. THOMSON, F.R.S.Ed., F.C.S., F.I.C., Vice-President of the Section, in the Chair.

Mr. BENNION read a letter from Mrs. Baxendell, acknowledging the receipt of a letter of condolence on the death of her late husband, who was formerly an active member of the Section.

Dr. BOTTOMLEY made some remarks on the application of Mendelejeff's Mathematical Method to the determination of the composition of solutions.

Mr. WM. THOMSON introduced the subject of the calorific value of carbon as diamond, and as graphite, and as it exists in combination in the gaseous state.

MICROSCOPICAL AND NATURAL HISTORY SECTION.

Annual Meeting, April 16th, 1888.

Professor W. C. WILLIAMSON, F.R.S., in the Chair.

The Hon. Secretary read the Thirtieth Annual Report of the Council of the Section.

The meetings have been held regularly each month during the session, and at each of them there has been a fair attendance, the interest being well sustained all through, and although there have not been many important papers read, there has been always a number of interesting communications made and specimens exhibited. The Council feels that if the advantages offered by the Section were more widely known, it would have the effect of inducing a large number of naturalists to join the Society.

During this session the Section has lost a former President and hearty supporter, Mr. JOSEPH BAXENDELL, F.R.S. He had the faculty, by his tact and kindly manner, of making himself greatly liked and esteemed by all who knew him, and his decease leaves a gap it will be hard to fill. Although for some time before his death he was unable to attend our meetings, he always took a great interest in what was going on at them.

Owing to removal from Manchester, inability to attend the meetings, etc., there have been several resignations, but these have been counterbalanced by the addition of new members and associates.

It will be seen from the Hon. Treasurer's report that the finances are in a satisfactory condition. To render the ,microscopes more complete, a set of object glasses has been procured. As a full account of the proceedings has been published from month to month, it is not necessary in this report to recapitulate what has been done at the various meetings; but the Council would point out the ready means of publication which the Society offers, as an inducement to members and associates to communicate original papers.

The following is a list of members and associates of the Section:—

Members.

ALCOCK, THOS., M.D.
ASHWORTH, J. J.
BAILEY, CHAS., F.L.S.
BARRATT, WALTER EDWARD.
BARROW, JOHN.
BICKHAM, SPENCER H., Junr.
BOYD, JOHN.
BROGDEN, HENRY, F.G.S.
BROWN, ALFRED, M.D.
COTTAM, SAMUEL, F.R.A.S.
COWARD, EDWARD.
COWARD, THOMAS.
CUNLIFFE, ROBERT ELLIS.
DALE, JOHN, F.C.S.
DARBISHIRE, R. D., B.A., F.G.S.
DAWKINS, PROF. W. BOYD, M.A., F.R.S., F.G.S.
DENT, HASTINGS C., F.L.S.
DEANE, W. K.
FARADAY, FREDERICK JAS., F.L.S.
HODGKINSON, ALEX., B.Sc., M.B.
HURST, CHARLES HERBERT.
HOWORTH, HENRY HOYLE, F.S.A., M.P.
MARSHALL, PROF. A. MILNES, M.A., M.D., D.Sc., F.R.S.
MELVILL, J. COSMO, M.A., F.L.S.
MORGAN, J. E., M.D., M.A.
NICHOLSON, FRANCIS, F.Z.S.
SCHWABE, EDMUND SALIS, B.A.
WILLIAMSON, PROF. W. C., LL.D., F.R.S.

Associates.

BLACKBURN, WILLIAM, F.R.M.S.
BLES, E. S.
BROOKE, H. S., B.A., M.B.
CAMERON, PETER, F.E.S.
CHADWICK, HERBERT C.
COLLETT, E. PYEMONT.
CUNLIFFE, PETER.
CURTIS, F. R.
DAWSON, G. J. CROSBIE.
EARL, H. L., B.A.
FLEMING, JAMES, F.R.M.S.
HARDY, JOHN RAY.
HUET, FRANK, L.D.S., R.C.S.
HYDE, HENRY.
JONES, LESLIE, M.D.
KENNEDY, G. A.
KNOOP, H. L.
LEACH, W.
NOTON, JOHN, F.R.M.S.
PETTIGREW, J. B.
ROBINSON, J. B., F.R.M.S.
ROGERS, THOMAS.
SMITH, JOHN, M.R.C.S.
STIRRUP, MARK, F.G.S.
SINGTON, THEODORE.
TATHAM, J., B.A., M.D.
TORRANCE, W. LADD.
WARD, EDWARD, F.R.M.S.
YOUNG, SIDNEY, D.Sc.

Total 28 members and 29 associates, against 31 members and 27 associates at the corresponding period of last year.

The Hon. Treasurer submitted the annual balance sheet, a copy of which is herewith appended.

The Microscopical and Natural History Section of the Manchester Literary and Philosophical Society in account with the Parent Society for Grants from the Natural History Fund.

Dr. *From 15th April, 1887, to 14th April, 1888.* **Cr.**

Dr.

		£	s.	d.
1887.				
Apl. 15.	To Balance of Grant unexpended	16	6	1
	,, Balance	20	10	1
		£36	16	2

Cr.

		£	s.	d.
1887.				
Apl. 18.	By Milne Edwards' Crustacées, 3 Vols. and Atlas	1	12	0
June 16.	,, Lacordaire and Chapuis' Coléoptères, 14 Vols. and Atlas	7	0	0
Aug. 2.	,, Challenger Publications, 4 Vols.	7	18	4
Sep. 19.	,, Do., Zoology, Vols. 20, 21	4	11	8
Oct. 28.	,, Do. do. ,, 22	2	1	8
1888.				
Feb. 16.	,, Fauna und Flora d. Golfes von Neapel, Vols. 7, 8	6	0	0
Mar 23.	,, D'Orbigny's Dictionnaire d'Histoire Naturelle, 16 Vols	4	10	0
Apl. 4.	,, Fowler's Coleoptera, 15 parts	3	2	6
		£36	16	2

By Balance.............£20 10 1

Mark Stirrup, Treasurer, in account with the Microscopical and Natural History Section of the Manchester Literary and Philosophical Society.

Dr.

		£	s.	d.
1887.				
Apl. 15.	To Balance in hand and in Bank	52	8	6
Dec. 20.	,, Interest allowed by the Bank	0	13	2
1887-88.	,, Subscriptions and Arrears from 15th April, 1887	25	0	0
		£78	1	8

Examined and found correct,

(Signed) JOHN B. PETTIGREW,
HERBERT C. CHADWICK.

14th April, 1888.

Cr.

		£	s.	d.
1887.				
Apl. 18.	By P. Klincksieck, Milne Edwards, Crustacées	1	12	0
June 16.	,, Do., Lacordaire's Coléoptères	7	0	0
July 6.	,, C. Simms & Co., Circulars, &c.	1	10	6
,,	,, J. E. Cornish, Naturalist & Microscopical Journal	0	9	10
Aug. 2.	,, Challenger Publications, 4 Vols.	7	18	4
Sep. 19.	,, Do., Zoology, Vols. 20 & 21	4	11	8
Oct. 28.	,, Do., Microscopical Journal and Naturalist	0	9	10
,,	,, Do., Challenger, Zool., Vol. 22	2	1	8
Nov. 15.	,, Wm. Roscoe, Donation voted for Services	5	0	0
,,	,, Do., Postages and Parcels, 7s. 5d., Tea, Coffee, &c., 29s. 4d.	1	16	9
Dec. 9.	,, J. E. Cornish, American Naturalist for 1888	0	18	0
Dec. 27.	,, Zoological Society for Zoological Record, Vol. 23	1	0	0
1888.				
Jan. 19.	,, J. E. Cornish, Microscopical Journal and Naturalist	0	9	10
Feb. 16.	,, Gurney & Jackson, "Ibis," 1888	1	1	0
,,	,, Williams & Norgate, Fauna und Flora d. Golfes v. Neapel, Vols. 7 and 8	6	0	0
Mar. 12.	,, Jno. Boyd, Oxygen Gas, Postages, &c.	0	15	6
Mar. 21.	,, Jas. Collins & Co., Envelopes	0	5	3
Mar. 28.	,, Chas. Simms & Co., Circulars, &c.	2	2	0
Mar. 23.	,, B. Quaritch, D'Orbigny's Dictionnaire d'Histoire Naturelle, 16 Vols.	4	10	0
Mar. 29.	,, Jno. Boyd, Object Glasses for Microscope	4	14	6
Apl. 4.	,, J. E. Cornish, Fowler's Coleoptera, 15 parts	3	2	6
	,, Chas. Hargreaves, Postages and Parcels, 19s. 4d., Tea, Coffee, &c., £2	2	19	4
	,, Mark Stirrup, Postages (2 Sessions)	0	3	0
	,, Bank Cheque Book Stamps.	0	2	1
	,, Balance in Manchester and Salford Bank (St. Ann Street)	17	8	1
		£78	1	8

On the motion of Mr. C. Bailey, seconded by Mr. J. Cosmo Melvill, the report and accounts were adopted.

Mr. F. R. CURTIS was elected an associate of the section.

The following gentlemen were elected officers and members of council for the ensuing session :—

President.

J. COSMO MELVILL, M.A., F.L.S.

Vice-Presidents.

CHARLES BAILEY, F.L.S.
ALEX. HODGKINSON, B.Sc., M.B.
Prof. W. C. WILLIAMSON, LL.D., F.R.S.

Hon. Treasurer.

MARK STIRRUP, F.G.S.

Hon. Secretary.

JOHN BOYD.

Council.

W. BLACKBURN, F.R.M.S.
PETER CAMERON, F.E.S.
H. C. CHADWICK.
R. E. CUNLIFFE.
R. D. DARBISHIRE, B.A., F.G.S.
F. NICHOLSON, F.Z.S.
THOMAS ROGERS.
THEODORE SINGTON.

Mr. P. CAMERON, F.E.S., exhibited specimens of spiders and ants to show mimicry, also *Arenetra pilosella*, Grav., a genus and species of *Ichneumonidæ* new to the British fauna. It was taken on Ben Lawers at Easter last year, on the snow, at an elevation of over 2,500 feet.

Mr. H. C. CHADWICK showed under the microscopes specimens of a new species of parasitic Copepoda *Lichomolgus sabellæ*, discovered by him August, 1887, clinging by means of its peculiarly modified posterior antennæ to the branchial filaments of *Sabella penicillus*, a tubicolous annelid found in great abundance on the beach at Beaumaris.

Mr. P. CAMERON, F.E.S., read a paper entitled "Descriptions of twenty-three new species of Hymenoptera."

Mr. J. COSMO MELVILL, M.A., F.L.S., exhibited his collection of *Cypræa*, and read a paper entitled "A survey of the genus Cypræa (Linn.), its Nomenclature, Geographical District, and Distinctive Affinities; with descriptions of two new species, and several varieties."

Annual General Meeting, April 17th, 1888.

Professor OSBORNE REYNOLDS, LL.D., F.R.S., in the Chair.

Mr. E. LEADER WILLIAMS, M.I.C.E., and Mr. JAMES ARTHUR HUTTON, of Manchester, were elected ordinary members of the Society.

The following gentlemen were elected honorary members of the Society :—Professor F. ZIRKEL, University of Leipsic; Professor GUSTAVE DEWALQUE, University of Liége; Professor JOHANN WILHELM HITTORF, Polytechnicum, Munster; Professor S. CANNIZZARO, University of Rome.

The annual report of the Council was presented.

Annual Report of the Council, April, 1888.

The annual balance sheets, prepared by the Treasurer, show that the finances of the Society are in a less straitened condition than they were a year ago, the debit balance of the General Account of £195. 16s. 8d. having been reduced to £21. 5s. 4d. on the 31st March, 1888, at which date the funds in hand amounted to £218. 5s. 7d.

The sources of income are set forth in the accompanying statement, where they are compared with the figures of the previous year. The Societies which now make use of the premises are the Manchester Geological Society, the Manchester Medical Society, the Manchester Photographic Society, and the Manchester Scientific Students' Association. The Manchester Microscopical Society has removed to other quarters.

As regards the credit side of the account, full details of the items constituting the ordinary expenditure were given in the reports of the two preceding years, and it is necessary to allude here only to those which indicate any important change.

In *Charges upon Property* is a small item for the cost of affixing tablets of names to the portraits of distinguished men which hang upon our walls, and of the marble busts in the possession of the Society.

House Expenditure.—During the Meeting of the British Association in Manchester last autumn, the Society's rooms were thrown open to the members of the Association, and the Society was honoured by the presence of many of its foreign honorary members. In this connection your Council has gratefully to acknowledge the liberality of the Local Committee of the British Association in making a prospective grant to the Society of the moiety of any surplus funds subscribed to meet the expenses of the Manchester meeting, and also the present of the handsome Library desk which stands in the Natural History Room, "in recognition of services rendered by the Society."

In *Administrative Charges*, the salary of the Curator and Assistant Secretary terminated at the quarter ending 30th June, 1887, after which date your Council decided to abolish the office. In the last report it was stated that the Society's respected housekeeper and collector, Mr. William Roscoe, had felt obliged, through failing health, to tender his resignation, but at the request of the officers, he continued to discharge the duties of his post until the conclusion of the meeting of the British Association. Upon the occasion of his leaving, the President, on behalf of the members, presented Mr. Roscoe with a purse containing £40, in recognition of his faithful services, accompanied by an expression of regard engrossed on vellum. In November last, your Council appointed as clerk and housekeeper, Mr. Charles Hargreaves, at a slightly higher salary than was paid to his predecessor; but advantage was taken of the opportunity to make some changes in the duties of the office in respect to clerical work, such as entering daily the donations to the Library, recording the publications received from Societies under their respective names, &c. The Council at the same time discontinued the additional remuneration for attendance on Sections and Societies formerly paid, preferring to make the salary offered an inclusive one for all the duties required.

In the *Publishing Account*, as compared with the previous year, there is a considerable diminution in the expenditure, due to several causes, some of which were alluded to in last year's report. The chief economy lies in the alteration in the form of publication of the papers read before the Society, as particularised in the previous report, and your Council has reason to believe that the change is acceptable to the members, as leading to a more rapid and regular publication, and in the improved typography and paper of the new issue. Soon after the new and consolidated form of publication had been resolved upon, the Council learned with extreme regret of the death of the editor of the Society's publications, their old and valued friend Mr. Joseph Baxendell, F.R.S. At the earnest request of his colleagues, one of the Society's secretaries, Mr. Frederick James Faraday, F.L.S., accepted the post of honorary editor, and his duties commenced with the first number of the 4th series of the Society's *Memoirs and Proceedings*.

Mr. Alfred Brothers, F.R.A.S., during the Session 1886-7, had presented to the Council an index which he had made of the Society's *Memoirs*, 2nd Series, Vols. XIII. to XV., and 3rd Series, Vols. I. to X. The consideration of this index has led your Council to arrange for the preparation and publication of an index of the whole of the volumes of *Proceedings* and *Memoirs* of the Society since its foundation, and in the preparation of such index the work of Mr. Brothers will be utilized.

It will be noticed from the summary of the accounts which follows the balance sheet, that the *Fire Account* has been closed by the balance of £60. 12s. 7d., which remained at the credit of that account last year, being transferred to the General Account of the Society.

The Hon. Librarian reports that the number of books, pamphlets, and part volumes received is about the same as last year. Nothing has been spent on binding, but it is hoped that the funds of the Society will allow of a grant being made for this most urgent and necessary purpose during the coming year, to supplement the £34. 18s. 2d which remains at the credit of the Binding Fund.

The Council considers it desirable to continue the system of electing sectional Associates, and the usual resolution will be submitted for the approval of the members at the Annual General Meeting.

The number of members on the roll on the 31st March, 1888, was 130, or 6 less than at the corresponding date last year. 7 new members have been elected during the Session; 10 have resigned; and 3 have died; viz., Mr. Joseph Baxendell, F.R.S., F.R.A.S., Professor Balfour Stewart, LL.D., F.R.S., and Mr. Charles Moseley.

An elaborate memoir of Mr. BAXENDELL, prepared at the special request of the Council by Dr. James Bottomley, B.A., F.C.S., was read before the members, and will be found in the present volume of *Memoirs and Proceedings*. To the record of Mr. Baxendell's life and work therein given, the Council has only to add an expression of its sense of the stimulating influence which Mr. Baxendell exercised in connection with the work of the Society. He will be remembered by his colleagues and the members generally, not merely for the value of his official services and the high importance of his own contributions to science, but for the keen and encouraging interest which, up to the end of his long life, he uniformly manifested in the work of the younger members, even when it lay outside his own special lines of research.

The Council has keenly felt the heavy loss sustained by the Society in the death of Professor BALFOUR STEWART, only a few weeks after the opening of the session of his first year as President. Professor Arthur Schuster, Ph.D., F.R.S., at the request of his colleagues, has undertaken to prepare an account of Dr. Stewart's life and work, which will appear as a memoir in the volume of *Memoirs and Proceedings* for the session now closing.

Mr. CHARLES MOSELEY was elected a member of the Society only near the end of the session 1886-7, and as his death occurred before the opening of the subsequent session, his connection with the Society was of very brief duration. During the interval, however, he gave evidence of his warm sympathy with its objects by the prominent part he took in the work of entertaining the British Association during its third visit to Manchester. Mr. Moseley was born in Manchester in 1839, and died at his residence, Grangethorpe, Rusholme, October 1st, 1887. He was remarkable for kindness and affability, combined with extraordinary energy. The earlier part of his career was devoted to the development of his business as an india-rubber manufacturer, at the Chapelfield Works. His first appearance in public life was on his acceptance of the office of Chairman of the Manchester Aquarium Company, with the hope of rescuing that institution from its embarrassments. During this period he gave a cordial, appreciative, and enterprising support to every attempt to maintain the Aquarium as a place of educational recreation and scientific study for the people of Manchester. The writer of this notice was closely associated with Mr. Moseley in the efforts then made, and remembers with peculiar pleasure his frank and unflagging co-operation. These efforts proved futile. The closing of the Aquarium about coincided with the appearance of Professor Graham Bell with his telephone, at the Plymouth meeting of the British Association in 1877. Mr. Moseley was one of the first to realise the commercial importance of the discovery, and immediately set to work to introduce it in this part of the country. The writer witnessed his first trials with the instrument at the Chapelfield Works, and well remembers the enthusiasm and confidence with which he spoke of its future. Later on, as Chairman of the Lancashire and Cheshire Telephone Company, Mr. Moseley carried on with singular energy and ability a contest with the Post Office in order to promote the development of long-distance telephoning, which the Government endeavoured, under the Telegraphs Act, to prevent. As a result of Mr. Moseley's severe labours and frequent interviews with the Postmaster-General (Mr. Fawcett) the "trunk-line" system, by which it is possible for most of the Lancashire towns to hold communication with each other, was established. He also took a strong interest in the development of electric lighting. He was a Director of the Edison Electric Light Company, and his own residence was lighted throughout by electricity. Mr. Moseley was a leading member of the Consultative Committee formed to prepare an independent report on the Manchester Ship Canal project after the failure of the first attempt to raise the capital, and was conspicuously influential in connection with the subsequent successful launching of the enterprise. As Chairman of the Music, Electric Lighting, Refreshments, and Gardens Committee of the Manchester Jubilee Exibition, Mr. Moseley contributed powerfully to the extraordinary success of that memorable undertaking. Few men have compressed so much and such important public work within the short space of about ten years, and there can be no doubt that had his life been spared he would have proved a valuable and earnest friend of the Society.

Death has also removed the following Honorary Members from the Society's roll, viz.:—Mr. J. B. Dancer, F.R.A.S., Professor A. de Bary, and Professor Asa Gray. Memorial notices of the two last-named by Mr. Charles Bailey, F.L.S., have already been published in the present volume of *Memoirs and Proceedings*. In consideration of Mr. Dancer's long connection with the Society it is fitting that a more detailed record of his life and work should also be included.

JOHN BENJAMIN DANCER was born in London on October 8, 1812, and may be said to have been born an optician, his father and grandfather having been makers of optical and scientific instruments. In 1818 his father, Mr. Josiah Dancer, removed to Liverpool, where he carried on the business of optician and philosophical instrument maker; he was also a public lecturer on science, and was an active promoter of the Mechanics' Institute and Literary and Philosophical Institution of Liverpool. The foundation of Mr. Dancer's optical knowledge was laid in his father's workshop. He also assisted his father in his lectures, and very early in life evinced a strong bias for mechanical and scientific pursuits. In 1835 the father died, and the business was afterwards carried on by the subject of this sketch.

After a few years Mr. Dancer removed to Manchester, where, in 1842, he was elected a member of this Society, of which he was in 1884 elected an honorary member. In 1845 he became a Fellow of the Royal Astronomical Society. In the successful exhibitions which were held many years ago at the Mechanics' Institution, both in Cooper Street and afterwards in David Street, Mr. Dancer took a very important part. It was he who suggested the application of photography to the magic lantern, and who, by the use of the lime-light, or Drummond light, as it was then called, made such application possible. The exhibition of photography on so colossal a scale took the world by surprise, and this grand application of the marvellous art, which has now become so familiar, was received with the admiration it deserved. Mr. Dancer's services to the lantern did not end with the application of photography to it ; he also improved the arrangement of the optical parts, producing a clearer image and a flatter field than had before been obtained. At the Mechanics' Institution Exhibitions Mr. Dancer was in no small measure responsible for the "fairy fountain," or, as it was first called, the "optical chromatic fountain." The fairy fountain of the Jubilee Exhition of 1887 was an extension of the original idea, and though shown on a much grander scale and in the open air, did not excel the beauty of the original Mechanics' Institution fountain.

A complete list of the instruments, apparatus, and processes in the invention or improvement of which Mr. Dancer was concerned is too considerable to reproduce here. In 1838 he suggested the introduction of earthenware porous jars to separate the two solutions used in voltaic batteries, which before this time was effected by means of bladder or other animal tissue. Porous jars have since been universally used. Dr. Golding Bird, in his "Elements of Natural Philosophy," published in 1839, gave Mr. Dancer credit for the invention of the porous jar ; but that is the most conspicuous acknowledgment he received for an improvement of the very greatest importance to science. In the same year he invented a still more important instrument, namely, the automatic contact breaker, or the vibrating interrupter—an instrument of universal application at the present day wherever electricity is employed for telegraphy or signalling. Again, in 1838, and resulting from the same experiments, came the deposition of metallic copper by voltaic electricity. This was the beginning of electro-plating, of which art Mr. Dancer was really the inventor, though others have taken the credit of it. Among other improvements of batteries made by Mr. Dancer there was the introduction of crimped or corrugated plates, so as to give a larger acting surface—a device which has been the subject of recent patents by some who know nothing of Mr. Dancer's having forestalled them by half a century.

In 1839 he introduced photography to Liverpool, working Daguerre's process, and in 1841 he was the first to do the same for Manchester, which had not yet seen a photographic camera. In the same year he commenced microscopic photography on Daguerrotype plates, and this wonderful art he perfected in 1852, when the introduction of the collodion process much simplified this and every other photographic process. These tiny examples of photography excited the warmest admiration and commendation of Sir David Brewster and other distinguished men. Mr. Dancer's diffidence prevented him from claiming for himself in this as in other discoveries the acknowledgment that was his due. The invention of micro-photographs was claimed elsewhere, but after a full inquiry by Mr. Joseph Sidebotham, Mr. Edward W. Binney, and the Manchester Photographic Society, Mr. Dancer's claim was allowed. In his record Mr. Sidebotham wrote in 1859: "Mr. Dancer's modesty will not allow him to speak of his own discoveries, but I am sure you all join in the annoyance I have felt in seeing persons coolly claim as their *own new discoveries* what our respected townsman has accomplished so many years ago." In 1853 Mr. Dancer invented the twin-lens stereoscopic camera; that is, a camera with two lenses placed side by side, at a short distance apart. Before Mr. Dancer took the matter in hand photographs for the stereoscope were taken with a single camera, which was moved for the second picture, and operators could not agree as to the proper amount of movement; some advocated eight inches, and some so much as twenty-four. Mr. Dancer was convinced that the proper separation was the ordinary distance between the eyes of a human being, and made his camera under this idea; from that time no other form of camera has been used.

Omitting several other instruments which Mr. Dancer improved, mention must be made of his connection with Dr. Joule in his heat experiments and discoveries. Dr. Joule found the necessity for accurate thermometers, and with Mr. Dancer's assistance determined to make them for himself. The result was the production of a new thermometer, the first made in England with any pretentions to accuracy. Mr. Dancer arranged the apparatus for measuring the internal capacity of the bore of the thermometer tubes, and constructed for Dr. Joule the apparatus which he employed in his determination of the mechanical equivalent of heat, also a tangent galvanometer and other original instruments.

When Mr. Dancer established himself as an optician in Manchester, his presence soon made itself felt amongst the few microscopists then living in the district. Good microscopes were then costly, and worthless ones very common. Mr. Dancer successively brought out several forms of instruments, as excellent in their mechanical and optical arrangements as they were moderate in price. Instruments fully equal to the requirements of original research were thus brought within the reach of many whose observing faculties were more conspicuous than their financial resources. It would be difficult to over-estimate the stimulus which Mr. Dancer thus gave to Manchester microscopy; it cannot be doubted that the present energy of our local microscopists is the direct outcome of the impulse which their means of research then received.

Latterly Mr. Dancer lost his most precious possession—

his eyesight—not suddenly, but by degrees. In spite of this, his active mind never lost its interest in the studies and discoveries of his earlier years. By his numerous friends his society was to the last highly appreciated, and his modest and kindly disposition greatly enhanced the pleasure and advantage of his conversation. His single-minded devotion to every branch of physics was not less remarkable than his unfailing industry and the inventive genius by which it was directed to results of no ordinary importance to the mechanician and the lover of natural science. He died at his residence, Greenhill Street, Greenheys, on November 24th, 1887.

The following papers and communications have been read at the ordinary meetings of the Society during the past session, or will be read this evening:—

OCTOBER 18th, 1887.
"On the possible equations expressing the decomposition of Potassic Chlorate by Heat," by James Bottomley, D.Sc., B.A., F.C.S.

NOVEMBER 1st, 1887.
"Pasteur and Faraday: Note on Dr. Tyndall's Introduction to the English Edition of the 'Histoire d'un Savant par un Ignorant'," by F. J. Faraday, F.L.S.

NOVEMBER 15th, 1887.
"On the Electrical Attraction of Quartz and the unsuitability of this substance as a protecting medium for compasses, watches, etc.," by Alex. Hodgkinson, M.B., B.Sc.

NOVEMBER 29th, 1887.
"The effect of the small variation of the density of the atmosphere on the amplitude of plane waves of Sound approaching the earth," by Ralph Holmes, B.A.

DECEMBER 13th, 1887.
"Memoir of the late Joseph Baxendell, F.R.S., F.R.A.S.," by James Bottomley, D.Sc.

DECEMBER 27th, 1887.
"Note on the Bi-centenary of the *Principia*," by James Smith.

JANUARY 10th, 1888.
"An application of Huyghens' Principle to a spherical wave of light," by R. F. Gwyther, M.A.

JANUARY 17th, 1888.

Correction to "On the Composition of projections in geometry of two dimensions," by James Bottomley, D.Sc. (See Vol. X., 3rd Series, *Memoirs*).

JANUARY 24th, 1888.

"An additional Note on the equations expressing the decomposition of Potassic Chlorate by heat," by James Bottomley, D.Sc.

"On the Union of Hydrogen and Nitrogen," by Prof. H. B. Dixon, M.A., F.R.S.

FEBRUARY 7th, 1888.

"Notice of Dr. A. de Bary and Dr. Asa Gray," by Charles Bailey, F.L.S.; "Notice of the late Dr. J. T. Boswell," by Charles Bailey, F.L.S.

"Note on an erratic block observed during excavations for a sewer in Oxford Street, Manchester," by Percy F. Kendall, Assistant Lecturer on Geology at the Owens College, Manchester. Communicated by Thomas Kay.

FEBRUARY 14th, 1888.

"Notes on a small collection of Mosses from Mauritius," by J. Cosmo Melvill, M.A., F.L.S.

FEBRUARY 21st, 1888.

"On the change of incidence of Small-Pox at different ages during the years 1848-86." Part I. By R. F. Gwyther, M.A.

"A method of calculating the Electrostatic Capacity of a Conductor." By Henry Holden, B.Sc., Bishop Berkeley Fellow in Physics at the Owens College, Manchester. Communicated by Prof. A. Schuster, Ph.D., F.R.S.

MARCH 6th, 1888.

"On the change of incidence of Small-Pox at different ages." Part II. By R. F. Gwyther, M.A.

APRIL 3rd, 1888.

"Note on a Nickel Arsenide." By H. E. Brothers, A.I.C., F.C.S. Communicated by Alfred Brothers, F.R.A.S.

APRIL 17th, 1888.

"A Survey of the genus Cypræa (Linn.), its Nomenclature, Geographical District, and Distinctive Affinities; with descriptions of two new species and several varieties." By J. Cosmo Melvill, M.A., F.L.S.

"Descriptions of twenty-three new species of Hymenoptera." By P. Cameron. Communicated by Charles Bailey, F.L.S.

"Memoir of the late Professor Balfour Stewart, LL.D., F.R.S." By Prof. A. Schuster, Ph.D., F.R.S., F.R.A.S.

It was moved by Mr. Harry Grimshaw, F.C.S., seconded by Mr. John Bell Millar, B.E., and resolved, "That the Annual Report be adopted and printed in the Society's *Memoirs and Proceedings*."

It was moved by Dr. A. Hodgkinson, B.Sc., seconded by Mr. William Thomson, F.R.S.E., F.C.S., and resolved :—"That the system of electing Sectional Associates be continued during the ensuing session."

On Professor Schuster expressing a wish to be relieved of the duties as one of the Society's Secretaries, it was moved by Dr. James Bottomley, B.A., F.C.S., seconded by Mr. Charles Bailey, F.L.S., and resolved :—"That the thanks of the Society be presented to Dr. Schuster for his past services."

The following gentlemen were elected Officers of the Society and Members of the Council for the ensuing year :—

President.

OSBORNE REYNOLDS, M.A., LL.D., F.R.S.

Vice-Presidents.

WILLIAM CRAWFORD WILLIAMSON, LL.D., F.R.S.,
FOREIGN MEMBER OF THE ROYAL SWEDISH ACAD. SC.

SIR HENRY ENFIELD ROSCOE, B.A., LL.D., D.C.L., F.R.S., F.C.S., M.P.

JAMES PRESCOTT JOULE, D.C.L., LL.D., F.R.S., F.C.S.,
CORR. MEM. INST. FR. (ACAD. SC.) PARIS, AND ROY. ACAD. SC. TURIN.

ARTHUR SCHUSTER, PH.D., F.R.S., F.R.A.S.

Secretaries:

FREDERICK JAMES FARADAY, F.L.S., F.S.S.
REGINALD F. GWYTHER, M.A.

Treasurer.

CHARLES BAILEY, F.L.S.

Librarian.

FRANCIS NICHOLSON, F.Z.S.

Other Members of the Council.

JAS. BOTTOMLEY, B.A., D.SC., F.C.S.
JOHN BOYD.
HAROLD B. DIXON, M.A., F.R.S.
WILLIAM HENRY JOHNSON, B.SC.
JAMES COSMO MELVILL, M.A., F.L.S.
S. B. WORTHINGTON, C.E.

MANCHESTER LITERARY AND

Charles Bailey, Treasurer, in Account with the Society,

Dr. *Statement of the Accounts*

	1887-8.						1886-7.		
1888—March 31st:—	£	s.	d.	£	s.	d.	£	s.	d.
To Cash in hand, 1st April, 1887				1	6	7	88	2	10
To Members' Contributions:—									
Arrears 1884-5, 1 Subscription at 42s.	2	2	0						
,, 1885-6, 5 ,, ,, ...	10	10	0						
,, 1886-7, 10 ,, ,, ...	21	0	0						
Old Members, 1887-8, 103 Subscriptions at 42s.	216	6	0						
,, 1888-9, 2 ,, ,, ...	4	4	0						
New Members, 1887-8, 3 ,, ,, ...	6	6	0						
,, ,, 3 Half-Subscriptions, at 21s.	3	3	0						
, ,, 6 Admission Fees at 42s.	12	12	0						
Old Member, Compounding Fee (Mr. Charles Lowe)	26	5	0						
				302	8	0	291	18	0
To Library Subscriptions, One Associate's, 1887-8, at 10s.				0	10	0	1	0	0
To Contributions from Sections, 1887-8:—									
Physical and Mathematical Section				2	2	0	4	4	0
To Contributions towards Curator's Salary, 1886-7							10	0	0
To Contributions towards half-cost of Gas Bags, &c., 1886-7							3	0	0
To use of the Society's Rooms, 1887-8:—									
Manchester Medical Society, to 30th Sept., 1887	25	0	0						
Manchester Microscopical Society, to 31st Dec., 1887	30	0	0						
Manchester Photographical Society, to 30th Sept., 1887	25	0	0						
Manchester Scientific Students' Association, to 30th Sept., 1887 ..	25	0	0						
				105	0	0	116	0	0
To Sale of the Society's Publications, 1887-8				0	18	9	9	3	6
To Natural History Fund, 1887-8:—									
Dividends on £1,225, Great Western Railway Co. Stock				59	8	0	59	4	2
To Bank Interest, less Bank Postages, 1887-8				0	7	7	2	13	5
To Centenary Fund, 1886-7				..	..	..	22	10	4
To Binding Fund, 1887-8:—									
Donations, as per detailed list on page 152 "Proceedings" 1886-7 ..				31	5	0	42	7	0
To Fire Account, 1886-7				..	..	..	245	9	3
				£503	5	11	£895	12	6

1888.—April 1. To Cash in Manchester and Salford Bank, Limited	£218	5	7

PHILOSOPHICAL SOCIETY.

from 1st April, 1887, *to the* 31*st March,* 1888, *with a Comparative for the Session* 1886-1887.

Cr.

1888.—March 31st:—	1887-8. £ s. d.	1887-8. £ s. d.	1886-7. £ s. d.	1886-7. £ s. d.
By Charges on Property:—				
Chief Rent (Income Tax deducted)	12 10 7		12 9 8	
Income Tax on Chief Rent	0 7 4		0 16 9	
Insurance against Fire	13 17 6		6 12 8	
Repairs, &c.	2 13 10		1 9 1	
Tablets to Portraits	3 5 0		.. .. ..	
By House Expenditure:—		32 14 3		21 8 2
Coal, Gas, Candles, Water, &c.	28 9 9		25 1 0	
Tea, Coffee, &c., at Meetings	16 15 4		15 18 6	
Cleaning Brushes, &c.	5 2 9		4 8 9	
Gas Bags, Pressure Boards, and Carrier Frame	.. .. ..		6 7 6	
Expenses in connection with British Association	4 14 3		.. .. ..	
Step ladder for Library	1 10 0		.. .. ..	
By Administrative Charges:—		56 12 1		51 15 9
Curator and Assistant Secretary	17 10 0		70 0 0	
Clerk and Housekeeper	60 10 0		57 4 0	
" " Extra Remuneration	.. .. ..		4 0 0	
Postages and Carriage of Parcels	19 6 11		21 2 10	
Attendance on Sections and Societies	.. .. ..		12 4 0	
Stationery, Printing Circulars, and Receipts	12 2 1		14 17 0	
Distributing 'Memoirs'	1 19 0		.. .. ..	
Legal Charges	1 1 0		6 14 0	
Advertising, &c., for Clerk and Housekeeper	1 19 9		.. .. ..	
By Publishing:—		114 8 9		186 1 10
Printing and Binding 'Memoirs'	.. .. ..		114 2 6	
Printing 'Proceedings'	29 13 6		51 13 0	
Printing 'Memoirs and Proceedings,' new series	3 16 9		.. .. ..	
Wood Engraving and Lithography	6 0 6		25 2 6	
Editor of the Society's Publications	.. .. ..		50 0 0	
Binding 'Proceedings'	4 1 3		.. .. ..	
By Library:—		43 12 0		240 13 0
Binding Books (from fund specially contributed)	.. .. ..		38 13 10	
Books and Periodicals	16 2 7		14 15 5	
Assistance in transferring books to new shelves	.. .. ..		12 0 0	
Assistant in Library	5 0 0		.. .. ..	
Palæontographical Society for the year 1888	1 1 0		1 1 0	
Ray Society for the year 1888	1 1 0		1 1 0	
Geological Record for the year 1879	0 10 11		.. .. ..	
By Natural History Fund:—		23 15 6		67 11 3
Works on Natural History	13 17 9		19 10 7	
Grant to Microscopical and Natural History Section	.. .. ..		25 0 0	
Plates for Natural History Papers in 'Memoirs'	.. .. ..	13 17 9	17 17 8	
By Centenary Fund:—				62 8 3
Expenditure 1886-7	.. .. ..	.. .. ..		87 16 6
By Fire Account.—Expenditure 1886-7	.. .. ..	.. .. ..		176 6 2
By Balance 31st March, 1888		218 5 7		1 6 7
		£503 5 11		£895 12 6

April 16th, 1888.

Audited and found correct,

(Signed) JOHN ANGELL,
ALEXANDER HODGKINSON.

		1887-8. £ s. d.	£ s. d.
Compounders' Fund :—			
Balance 1st April, 1887		125 0 0	
Compounding Fee—Mr. Charles Lowe		26 5 0	
Balance in favour of this Account, 31st March, 1888			151 5 0
Natural History Fund :—			
Balance in favour of this Account, 1st April, 1887		7 17 6	
Dividends received during the Session 1887-8		59 8 0	
		67 5 6	
Expenditure during the Session 1887-8		13 17 9	
Balance in favour of this Account, 31st March, 1888			53 7 9
Binding Fund :—			
Balance in favour of this Account, 1st April, 1887		3 13 2	
Donations received during the Session 1887-8		31 5 0	
Balance in favour of this Account, 31st March, 1888			34 18 2
			239 10 11
General Account :—			
Balance against this Account, 1st April, 1887	£195 16 8		
Expenditure during the Session 1887-8	271 2 7		
		466 19 3	
Transfer from Fire Account, 1st April, 1887	60 12 7		
Receipts during the Session 1887-8	385 1 4		
		445 13 11	
Balance against this Account, 31st March, 1888			21 5 4
Cash in Manchester and Salford Bank Limited, 31st March, 1888			£218 5 7

Ordinary Meeting, April 17th, 1888.

Professor OSBORNE REYNOLDS, LL.D., F.R.S., in the Chair.

Mr. CHARLES BAILEY, F.L.S., communicated a paper entitled "Descriptions of twenty-three new Species of Hymenoptera," by P. Cameron.

Mr. J. COSMO MELVILL, M.A., F.L.S., communicated a paper entitled "A Survey of the genus Cypræa (Linn.), its Nomenclature, Geographical District, and Distinctive Affinities; with descriptions of two new Species and several varieties."

Professor A. SCHUSTER, F.R.S., read a paper entitled "Memoir of the late Professor Balfour Stewart, LL.D., F.R.S."

Descriptions of twenty-three new species of Hymenoptera. By P. Cameron. Communicated by Chas. Bailey, F.L.S.

(Received April 17th, 1888.)

The chief interest of the following paper consists in its containing either descriptions of species belonging to genera or groups which have been very little studied, and which consequently are very little known; or descriptions of species of well-known genera from regions which have been hardly explored, at least as regards their Hymenopterous Fauna. Of the former class I may allude to the six new species of *Epyris*, of which three are European, including one from England, and to the six new parasitic Cynipidæ from Britain. Possibly the most important species described is the new species of *Ampulex* from Gibraltar, there having been only one European species described, the genus itself, too, being a remarkable one, and more representative of tropical than of temperate regions.

I have to express my indebtedness to Mr. J. J. Walker, R.N., for a small, but highly interesting, collection of Hymenoptera from Gibraltar; to Mr. J. Helms, of Greymouth, New Zealand, for an equally interesting collection from his district, and to Mr. J. Cosmo Melvill for the curious *Bracon* from Bogota.

I may be allowed to make here some observations on the question of the multiplication of "genera" in the Hymenoptera, as it appears to me that the creation of so many so-called "genera" may lead not only to confusion, but may be even positively injurious to the progress of the study of the Hymenoptera.

The late Prof. Arnold Foerster is the author who initiated the principle of minute analytical analysis in splitting up the old genera. That some of these genera may have been rather too widely defined may be granted; but it does not follow that Foerster's system was an improvement. If genera are to be formed, they should be defined, not as regards the German species, but as regards the species from all parts of the world. Once commence to define genera from one or possibly two characters and you then find yourself logically bound to the creation of an endless number of genera. The objections to most of the genera carried out on the Foersterian lines are that they do not apply to exotic species, and further, that in many cases the characters employed to define the genera are found to be specific rather than generic when traced through a series of species from all parts of the world. In working out the parasitic Hymenoptera for the "Biologia Centrali-Americana," I endeavoured to arrange the species according to Foerster's "genera," but I soon found out that it was impossible to do so—that in fact the species could not be referred to them; and that if Foerster's method was to be followed, the erection of a large number of "genera" must be attempted. There are, however, serious objections to that being done, with our present limited knowledge of exotic forms; not only so, but many of the characters employed by Foerster and his followers merge so much into one another that they are perfectly useless for purposes of generic diagnosis, *e.g.* the abdominal segments in *Pimplides*. Even as regards European species the method in many cases fails. Take, for example, Foerster's divisions of *Kleditoma*. Of these he has five, arranged according to the number of joints in the antennal club. If species were to be discovered with two- and one-jointed clubs, "genera" would logically have to be erected for them; more than that the species I have described in this paper under the name of *Kleditoma melanopoda* should form the type of a "genus," because it has no antennal club at all. Then again, the males of all these divisions have no distinctive characters; so that the "genera" are founded exclusively on the females.

As another example of the multiplication of genera, I may allude to the recent elevation by Herr Konow of some of the divisions of *Stronglogaster* and *Blennocampa* to generic rank. If these are to be accepted, a large number of genera must be formed for the American species; and I question very much if the characters employed by Herr Konow will not be found on examination to merge so much into one another as to be incapable of rigid definition. That all large genera fall into well marked groups is, of course, true; and in monographic works such groups should be defined; but it is questionable if anything is to be gained by giving them names. The naming of the species of *Blennocampa* (using the word in the Thomsonian sense), for example, is not greatly facilitated by certain of the groups being separated from it and given names.

The truth seems to be that the species of the larger genera arrange themselves differently in the various zoological regions. To carry out the present system of minute generic analysis can only lead to the creation of "genera," the characters of which are only applicable to the species of one region. With our present knowledge of the Hymenoptera, the system, to my mind, when carried to extremes, will do more harm than good, and may lead to great confusion; for it will render the identification of genera almost impossible when species are studied outside the limits of the region where such genera have been formed. Possibly in no order of insects is the question of generic definition more perplexing than in the Hymenoptera; the greater the reason, therefore, is there for care being exercised in the formation of new genera; as, unless this is done, it will simply lead to confusion and additions being made to an already too large synonymy.

TENTHREDINIDÆ.

SELANDRIA (?) ROTHNEYI, *sp. nov.*

Nigra-coerulea; coxis, trochanteribus posticis dimidioque basali tibiarum posticarum, albis; alis fere hyalinis. Long. 7 mm.

Hab. Barrackpore, Bengal (*G. A. J. Rothney*).

Antennæ shortly pilose, longer than the head and thorax united, the third joint slender, slightly curved, nearly one-fourth longer than the fourth; the 5th—8th joints produced sharply at the apices beneath; the 6th—8th much shorter than the fifth. Head: the face and clypeus covered with long white hair; clypeus truncated at apex; frontal area distinct, obscurely roughened; a short keel in the centre, which is depressed; sutures on vertex not reaching to the back of the head; eyes converging in front, reaching near to the back of the head. Body and legs shortly and sparsely covered with white pubescence; cenchri large, white; calcari about one-fourth of the length of the metatarsus; claws bifid. Second marginal cellule a little longer than the first; first transverse cubital nervure absent; transverse basal nervure received beyond the middle of the cellule; the second recurrent nervure is received about the same distance from the second transverse cubital nervure that the transverse radial is from the second transverse cubital.

If the first transverse cubital nervure were not absent this species agrees in neuration with *Selandria*. With the material at my disposal it is impossible for me to say if the absence of this nervure is normal; and I therefore leave the species in *Selandria*. If there are species similar to the species here described, it might be referred to *Aneugmenus*, but that I suspect was found on a *Selandria* which had the first transverse cubital nervure faint or absent; and, therefore, I am inclined to regard *Aneugmenus* as synonymous with *Selandria* (*cf.* Cameron, Mon. Brit. Hym. I. p. 264.)

EMPHYTUS AZTECUS, *sp. nov.*

Niger, fusco pubescens; labro, palpis, tegulis, linea pronoti, coxis, trochanteribus, basi et apice femorum, tibiis tarsisque anterioribus, albis; alis fusco hyalinis. ♂ Long. 5 mm.

Hab. Mexico, Orizaba, December (*F. D. Godman and H. H. Smith*).

Antennæ densely, but shortly, pilose; the third joint considerably longer than fourth. Head finely punctured; frontal area and vertical sutures indistinct; apex of clypeus transverse. Thorax shining; impunctate; cenchri large, white. Abdomen considerably longer than the head and thorax united. Transverse basal nervure received near the middle of the cellule; the second recurrent nervure a little before the middle.

Emphytus improbus Cresson is the nearest relative known of this species; *improbus* may be known from it by having the third, fourth, and fifth joints of the antennæ of nearly equal length; by the abdomen being "about as long as the head and thorax"; in the metatarsus being as long as all the other joints united, &c. *E. mexicanus* (Cam.) has only the knees and fore-tibiæ white.

CYNIPIDÆ.

ONYCHIA STRIOLATA, *sp. nov.*

Nigra; capite et thorace striolatis, breviter pilosis; tibiis tarsisque anterioribus, piceis; flagello antennarum subtus fusco; alis hyalinis, nervis pallide testaceis. ♂. Long. fere 4 mm.

Hab. Barrackpore, Bengal (*G. A. J. Rothney*).

Antennæ longer than the body, of nearly uniform thickness; the third and fourth joints subequal. Head and thorax opaque, covered with a short whitish pubescence. Head rugosely punctured, striolated on the vertex and behind the eyes; front slightly depressed, finely rugose; a straight keel runs down from the direction of each ocellus; mandibles piceous. Sides of pronotum coarsely striolated; the top a little depressed, finely rugose, this central part being distinctly separated from the striolated sides. Mesonotum coarsely rugose; parapsidal furrows wide, distinct; the space between the keels at the base crenulated; mesopleuræ shining, impunctated; excavated in the centre. Scutellum channelled; keeled down the centre; the foveæ at the base shining, impunctate; the sides whitish; the apical part with stout transverse keels; the apex almost transverse. Central part of metanotum shining, impunctate; separated by stout keels from the reticulated, densely pilose sides. Abdomen shining; the apical half of the petiole striolated above. The anterior legs shortly and sparsely covered with white hair; the posterior densely; the posterior tibiæ and femora opaque, absoletely punctured; the tibiæ channelled.

A larger species than *O. Westwoodi*, Dbm. differing from it otherwise in the front not being rugosely punctured and bearing three distinct longitudinal keels, the lateral keels, too, projecting more; in the sides of the pronotum being more strongly striolated; in the tegulæ being black, and the nervures whitish; and in the abdomen being longer, the petiole especially being as long as the hind coxæ, while in *O. Westwoodi* it is not half the length.

As bearing on the distribution of *Onychia*, I may remark that Mr. J. J. Walker, R.N., has taken *O. notata*, Fonsc., at Benzus Bay, Morocco.

KLEDITOMA NIGRIPES, *sp. nov.*

Nigra, geniculis tibiisque piceis, alis hyalinis, nervis piceis, antennis thorace longioribus, clava 3-articulata, abrupta. ♀. Long. 2·3 mm.

Hab. Dulwich (*T. R. Billups.*)

Black; knees and base of tarsi piceous; wings hyaline; nervures piceous-black. Antennæ longer than the head and thorax united; the third joint attennuate at the base, twice the length of the fourth, the fourth and fifth joints narrowed at the base, longer than broad; joints 6—10 moniliform, as broad as long; joint 11 distinctly thicker than the tenth, but shorter and thinner than the thirteenth, the three forming a well-marked club. Occiput striated. Sides of scutellum longitudinally striated; the discal fovea small, shallow, indistinct; apex of the scutellum below the cup forming a curved hook-shaped projection. Metanotum aciculate, depressed at the base, abdomen scarcely as long as the head and thorax united; the hair fringe thick, large, griseous. Radial cellule open at base and apex; the second abscissa of radius three-fourths of the length of the third.

This is the largest species of the section of *Kleditoma* with a 3-jointed club, and with the apex of scutellum prolonged into a sort of beak (= *Rhynchacis*, Foerster). It is most nearly related to *K. nigra*, but the much darker legs and wing nervures; the striated occiput, the more elongated radial cellule, which is widely open at base and apex, and the sharper beak-shaped apex of scutellum sufficiently distinguish it from the smaller *nigra*.

KLEDITOMA CRASSICLAVA, *sp. nov.*

Black, shining; the knees and tarsi piceous; wings yellowish-hyaline, the nervures piceous; abdominal hair-fringe whitish. Antennæ nearly as long as the head and thorax united; the 3-jointed club stout, thick; its basal joint distinctly shorter and narrower that the 12th. Apical margin of wing obtusely rounded, but very slightly incised. Apex of scutellum prolonged into a beak. Length 2 mm.

Hab. Bonar Bridge, Sutherlandshire. (*Cameron.*)

May be known from *K. nigra* by being larger and stouter, by the stouter antennal club, by the blacker legs, and by the apical margin of the wings being hardly incised.

KLEDITOMA CALEDONICA, *sp. nov.*

Black, shining; the four anterior knees, tibiae and tarsi, testaceous, the posterior and the trochanters piceous; wings hyaline, the nervures testaceous; the abdominal hair fringe griseous. Antennæ longer than the head and thorax united; the flagellum before the club slender; the 3-jointed club distinct, the joints conical, distinctly attenuated at base and apex; the 11th joint perceptibly shorter than the 12th. Radial cellule elongated; the second abscissa of radius fully one-fourth longer than the first; apical margin obtusely incised. Apex of scutellum not beak-shaped. Length 1 mm.

A smaller species than *K. striaticollis*, and easily known from it by the joints of the club being narrowed at base and apex and clearly separated.

Hab. Claddich, Loch Awe (*Cameron*).

KLEDITOMA STRIATICOLLIS, *sp. nov.*

Black, shining, the knees broadly, trochanters, base of femora, and tibiæ and tarsi, piceous; wings clear hyaline, the nervures testaceous. Antennæ as long as the head and thorax united; the three-jointed club abrupt; its joints of equal thickness; the basal a little shorter than the second; the ninth and tenth joints are thicker than the preceding and more globular. Radial cellule elongate; the second abscissa of radius perceptibly longer than the first; apical margin of wings obtusely incised. Abdominal hair fringe dense, griseous. Pronotum striolated. Apex of scutellum not beak-shaped. Length: 1½ mm.

Hab. New Galloway (*Cameron*).

KLEDITOMA MELANOPODA, *sp. nov.*

Nigra, geniculis, tibiis tarsisque, piceis, alis hyalinis, nervis testaceis; antennis longis, clava nulla. ♀. Long. 2·7 mm.

Hab. London District.

Black; the knees, and fore tibiæ, and tarsi, piceous; wings clear hyaline, the nervures piceous. Antennæ more than twice the length of the thorax; the third joint nearly one half longer than the fourth; the apical six joints longer and somewhat thicker than the preceding, but not forming a distinct club; the seventh joint shorter than the eighth. Occiput transversely striated; pronotum rather strongly longitudinally striated; sides of scutellum striolated; the cup lanceolate, the apical depression round and with two small foveæ behind it; scutellar foveæ large, deep, and longer than broad. Abdomen compressed, longer than the head and thorax united; the hair fringe long, griseous. Metanotum with an oblique slope, shining, impunctate, the centre hollowed, the sides keeled. Wings large. ♀

There is no described species with which *E. melanopoda* can be compared; nor can it be placed very well in any of Foerster's "Genera." The antennæ come nearest to those of *K. pygmaea;* but the apical six joints form a well-marked club in it, and the form of the radial cellule is very different; the radial cellule in *K. melanopoda* being formed as in *K. brevicornis, tetratoma*, &c.

EUCOILA GRACILICORNIS, *sp. nov.*

Nigra, nitida, flagello antennarum, ore, pedibusque, rufis; alis flavo hyalinis; antennis corpore longioribus; clava haud discreta. Long. 4 mm.

Hab. Banks of Clyde, near Cambuslang (*Cameron*).

Black; the flagellum and legs (except the basal three-fourths of the coxæ) red; the tegulæ piceous; wings yellowish-hyaline, the nervures testaceous. Antennæ filiform, longer than the body, the sixth and following joints not thicker than the fifth, elongated, much longer than broad; the third joint shorter than the fourth. Scutellum rugosely punctured; the cup suborbicular, narrowed at the base; the rim piceous; the fovea at apex large, wider than long. Hair on sides of metanotum moderately long, griseous. Abdomen not much longer than the thorax; its hair fringe, thick, griseous. Wings large; first abscissa of radius about three-fourths of the length of second, and both are distinctly curved; the third abscissa about the length of basal two united, slightly curved; cubitus reaching to the apex of the wing; apical fringe moderate. The male has the antennæ one and three-fourth times longer than the body; the third joint is shorter than the fourth.

Closely allied to *E. similis*, Cam., but that species has the antennæ not much longer than the body, and with the apical eight joints thicker than the preceding, and scarcely twice longer than broad; the wings are clear hyaline, the nervures paler, the cubitus does not reach to the apex of the wing, and the tegulæ are entirely red.

PROCTOTRUPIDÆ.

Epyris orientalis, *sp. nov.*

Niger, capite punctato; metanoto transverse striolato, alis fusco-hyalinis. Long. 10 mm.

Hab. Barrackpore, Bengal (*G. A. J. Rothney*).

Antennæ fuscous towards the apex; sparsely clothed with long white hairs; the third joint about one-fourth shorter than the fifth. Head shining, sparsely covered with long white hair; covered with large scattered punctures. Mandibles rufous towards the base and apex; sparsely covered with large irregular punctures and sparsely pilose. Pro- and mesothorax covered with longish fuscous hair; sparsely punctured; parapsidal furrows complete. Metanotum shining, transversely striolated, reticulated in the centre, and with two stout keels, which unite towards the apex of the metanotum; median segment transversely striolated. Abdomen at the apex covered with long hair. Legs thickly covered with white hair. Lower discoidal cellule complete; upper with the nervures obscure and faint.

Epyris hispanicus, *sp. nov.*

Niger, capite thoraceque rugoso punctatis, metanoto 7-carinato; ore, mandibulis, pro-mesothorace, cum scutello, rufis, antennis testaceis, vel apice fuscis; pedibus nigris, tarsis testaceis, coxis, trochanteribus femoribusque anteeis, rufis; alis fuscis, basi fasciaque medio lacteis. Long. 4½—7 mm.

Hab. Gibraltar (*J. J. Walker*, R.N.).

Antennæ stout, scarcely so long as the thorax; the flagellum shortly and sparsely covered with a white pile, the third joint about one-fourth longer than the second; the fourth is hardly so long as the second. Head sparsely covered with white hairs; strongly rugosely punctured all over; mandibles punctured at the base, the apex black.

Pronotum quadrate, almost transverse above in front; rugosely punctured and furrowed down the middle above, the sides longitudinally rugosely punctured, almost striolated; mesonotum punctured, but not very strongly, and rather irregularly; parapsidal furrows complete, diverging towards the front; scutellum punctured, if anything, more strongly than the mesonotum; mesopleuræ rugosely punctured; metanotum shining; there is a stout central keel; one on either side of it, which converge towards its apex, so as to almost touch; at a greater distance outside this than is the second keel from the central, is another stout keel, which also converges towards the apex; and outside this again, and quite close to the marginal keel, is another which runs almost parallel with the latter. The space between the keels is tranversely rugosely striolated, this being also the case with the median segment, but it is more regular and there is only a central keel. The sides of the metanotum project into stout teeth; the apex is convex (forming almost the segment of a circle); metapleuræ irregularly reticulated. Abdomen shining, shorter than the thorax; the apex and central segments somewhat thickly covered with longish white hairs. Legs thickly covered with a stiff white pile. Wings a little longer than the thorax; the lower discoidal cellule is open at the apex.

The above is described from a specimen 7 mm. in length, and with the wings longer than the thorax; but Mr. Walker sends specimens measuring from 4½ to 5½ mm. in length, which have the wings one-half or even one-fourth of the length of the thorax. In these the punctuation is less strongly developed, and the metanotal keels less distinct (especially those on either side of the central), but otherwise I cannot find any tangible differences. In the smaller specimens the punctuation varies in intensity; the amount of red on the anterior legs varies considerably, and the antennæ may be black, dull testaceous at the base.

EPYRIS APTERUS, *sp. nov.*

Niger, alatus; thorace rufo, nigro maculato; basi flagello antennarum, mandibulis, geniculis tarsisque, rufo-testaceis, capite sparse punctato, nitido; metanoto tricarinato. Long. fere 5 mm.

Hab. Gibraltar (*J. J. Walker*, R.N.).

First joint of antennæ curved, and thickened towards the apex; second a little longer than the third, which is somewhat longer than the fourth. Head shining, sparsely pilose; marked all over with shallow, distinctly separated punctures; eyes oblong, placed almost in the centre. Thorax shining, obsoletely punctured; the prothorax quadrate, the front rounded; mesonotum and scutellum almost impunctate; parapsidal furrows distinct, but shallow and narrow; metanotum impunctate, the centre three-keeled, the central keel straight, the lateral converging towards the apex, which is almost transverse, but, if anything, retreating in the centre. Abdomen shining, the apex bearing stiff white hairs. The thorax is red, except the prosternum, an irregular splash in the centre above, the mesopleuræ in front, the metanotum, except the central keeled part and more or less of the metapleuræ. The legs are covered with stiff white hairs. There are no wings.

In general coloration this species agrees closely with *E. hispanicus*, but the second joint of the antennæ being longer than the third, the head only slightly punctured, the thorax scarcely punctured, the pronotum not furrowed in the centre, and the metanotum, only having three keels, readily separate it.

The complete absence of wings may make the generic position of *E. apterus* a little doubtful; but the fact that *E. hispanicus* shows a tendency to losing the wings, and the complete parapsidal furrows leaves no doubt in my mind that it is a true *Epyris*.

EPYRIS TRICOLOR, *sp. nov.*

Coeruleus, flagello antennarum, coxis, trochanteribus, femoribus, abdominisque apice late, nigris; tibiis, tarsisque anterioribus testaceis; tarsis posticis fuscis; abdominis basi late rufo-testaceo; metanoto tricarinato; alis fuscis, nervis testaceis; stigmate radioque fuscis. ♂. Long. fere 5 mm.

Hab. New Forest (*P. Cameron*).

Antennæ stout, three-fourths of the length of the body; the third joint fully twice the length of the second, which is a little shorter than the fourth. Head broader than long, retreating behind the eyes, which are large, reach in front beyond the base of the antennæ and beyond the ocelli behind; shining, punctured, the punctures moderately large, shallow, and distinctly separated; a shallow furrow runs down from the front ocellus. Prothorax strongly punctured, longer than broad, narrowed and rounded towards the front; the prosternum bulging out. Mesothorax shining metallic; marked with scattered shallow punctures; parapsidal furrows complete, almost parallel; scutellum very shining, obsoletely punctured. Metanotum between the keels transversely striolated; the apex rounded, the bounding keel being continued on the inner side of the projecting sides, which are placed on a lower level than the keel; the central keels narrow; the central straight, the lateral slightly curved and converging towards the apex. Abdomen shorter than the thorax, shining, impunctate. Wings nearly as long as the thorax and abdomen united; the two discoidal cellules completely closed; the cubital nervure is continued beyond the upper. Legs almost bare; tips of the tarsi pale testaceous.

Taken by myself in the New Forest early in June.

Two British species of *Epyris* were described by Haliday in Ent. Mag. V., p. 519, namely:—

E. niger. Metathorace truncato, dorso tricarinato et cancellato; abdomine convexo; nervis costalibus conjunctis, and

E. subcyaneus. Metathorace dorso reguloso, apice rotundato ; abdomine depresso ; nervis costalibus disjunctis ; areola prae brachiali à stigmate remoto.

The latter species was described by Walker in Ent. Mag. IV., p. 432., pl. xvi., f. 6, under the erroneous name of *Niger* West., and Westwood (Thesa. Ent. Oxon., p. 158) changes the name to *Halidii*, on the ground that the name *Subcyaneus* is not characteristic. Westwood also describes in the above work two additional new species, namely, *E. fraternus* from Combe Wood, and *E. sæva* "ex Anglia." Thomson (Oef. af K. Vet. Akad. 1860, p. 453) describes a Swedish species *E. bilineata*, but from all these *E. tricolor* is readily known by the metallic blue head and thorax and testaceous abdomen. It may be as well to give the references to our British species.

1. *E. tricolor*, Cam. *supra*.

2. *E. niger*, Westwood, Phil. Mag. 1832. i. p. 129; Haliday, Ent. Mag. V. p. 519.

3. *E. subcyaneus*, Haliday, Ent. Mag. V. 519, *olim E. niger*, *l.c.* IV. p. 432, pl. xvi. f. 6.

E. Halidii, West., Thesa. Ent. Oxon., p. 158, pl. xvi. fig. 6.

4. *E. fraternus*, West., *l.c.*, p. 157, pl. xxx. fig. 2.

5. *E. sæva*, Westwood, *l.c.*, p. 158, pl. xxxi. fig. 6.

NOTE.—Dours (*Cat. Hymén. de France*, p. 112) records "*E. ruficollis*, Gir."; but I cannot find any reference to such a species in Giraud's papers, of which, I believe, I have the whole; and, therefore, suspect it is a manuscript name. The practice of recording species under manuscript names is not only useless, but entails endless trouble in endeavouring to find out if and where they have been described.

EPYRIS RUFIPES, *sp. nov.*

Niger, nitidus, sparse punctatus ; breviter pilosus ; metanoto aciculato ; antennis, mandibulis, tegulis, palpis, *pedibusque, rufis ; alis fere hyalinis ; stigmate fusco ; nervis testaceis* ♀. Long. 5 mm.

Hab. Mexico, Orizaba, December (*H. H. Smith and F. D. Godman*).

Antennæ as long as the thorax, stout, sparsely haired ; the scape curved on lower side, dilated at the apex, as long as the following three joints united ; the second joint a little longer than the third, narrowed at the base. Head shining ; sparsely punctured, the punctures widely and irregularly separated ; thorax finely aciculated, irregularly punctured ; scutellum impunctate ; metathorax strongly aciculated ; a keel down the centre ; and on either side of this central keel are some irregularly waved keels, most of which do not reach the apex of the metanotum, on which there is a distinct keel ; median segment finely transversely striated, hollowed in the centre. Abdomen shining and impunctate ; the apical three segments covered with pale hairs. Lower discoidal cellule entirely obliterated. Legs stout, covered with whitish hair ; the fore coxæ are for the greater part black.

EPYRIS PUNCTATUS, *sp. nov.*

Niger, crebre punctatus, albo hirtus, metanoto nitido, impunctato, tricarinato ; flagello antennarum rufo-testaceis ; palpis, trochanteribus, geniculis, tibiis tarsisque, testaceis ; alis hyalinis ; stigmato fusco, nervis testaceis. ♂. Long. fere 5 mm.

Hab. Mexico, Orizaba, December (*H. H. Smith and F. D. Godman*).

Antennæ longer than the thorax, rather densely pilose ; scape curved, as long as the second and third joints united ; the second one-third the length of the following, which is longer than the fourth. Head rugosely punctured ; eyes projecting ; front and oral region excavated deeply, the antennæ originating from large tubercles, situated in the centre of the excavation ; mandibles large, punctured, three toothed, reddish before the middle; the eyes are situated quite close to the base of the mandibles. Pro- and meso-thorax coarsely rugosely punctured, the pleuræ more irregularly and less strongly; scutellum shining, bearing a few indistinct punctures. Prothorax considerably narrowed in front, the sides with a slight curve, the pronotum in front transverse, projecting above the elongated prosternum. Metathorax shining, impunctate, except in the centre of the metanotum, which is aciculated and bears three keels, the central reaching a little beyond the middle, the lateral not half its length, the central towards the apex having a few transverse striæ. The apex of the metanotum has not a distinct margin; the median segment impunctate, shining, semi-perpendicular. Abdomen shorter than the thorax, the apical half sparsely covered with white hair; the apex broadly testaceous. Legs moderately stout, pilose; the tibiæ incline more or less to fuscous. Lower discoidal cellule completely traced.

PROCTOTRUPES MACULIPENNIS, *sp. nov.*

Fulvus, nitidus, fulvo hirtus, mesopleuris sternoque, nigris; alis flavo hyalinis, fusco bifasciatis. Long. 9 mm.

Hab. New Zealand, Greymouth (*Helms*).

Clypeus almost transverse, margined; front carinate, the sides depressed. Propleuræ deeply excavated; pronotum depressed in the middle, the sides broadly tuberculate; scutellum raised; a broad semi-circular furrow at its base; post scutellum not raised; a broad and wide depression on on either side of it; a broad and wide furrow at the base of the metanotum, which on either side, in front of this furrow, projects into a large stout tubercle, and there is a sharper and somewhat smaller tubercle in the centre; from the tubercles keels run down to the apex of the metanotum. Legs covered with a fulvous pubescence; the base of the hind coxæ inclining to black. The fuscous cloud in the wings commences at the base of the stigma, and extends to the apex, but is interrupted above by a large yellow cloud, which extends to the costa, but not to the opposite side of the wing. The hind wings are yellowish, smoky at the apex.

ICHNEUMONIDÆ.

PIMPLA JASON, *sp. nov.*

Ferruginea; nitida; antennis, tibiis, tarsisque posticis, nigris; alis, hyalinis, apice violaceis. ♀ *et* ♂. Long. 15 mm.; terebra 4—5 mm.

Hab. Interior of Colombia (*Wheeler*).

Antennæ as long as the body, stout, densely pilose. Clypeus rounded at apex, depressed slightly in front of it, and with a wide and deep furrow at the base; face slightly projecting in the centre; front depressed; ocelli bordered laterally by a furrow, mesonotum bearing a sparse short pubescence; scutellum with a deep, broad, wide depression at the base, this being keeled, the keel being continued down the sides of the scutellum to near its apex, where it becomes indistinct. Metanotum with two stout transverse keels near the apex. Petiole narrow, obscurely furrowed above at the base. The second segment bears a deep depression on either side at the base, and a longer and shallower one at the apex. Areolet oblique, elongated; the curved recurrent nervure is received beyond the middle.

BRACONDIÆ.

BRACON DOLICHOURA, *sp. nov.*

Niger; abdomine pallide ochraceo; facie longe pallide hirta; alis fuliginosis. Long. 12; terebra 127 mm.

Hab. Mountains S.W. of Bogota.

Antennae densely pilose; the scape with moderately long black hairs. Head shining, the vertex sparsely covered with long black hairs; the face more thickly with pale fuscous; front moderately depressed; the furrow narrow, but deep and distinct. Thorax shining, impunctate; the mesonotum sparsely, the metathorax more thickly and longly haired; metanotum with a very gradual slope to the apex. Base of petiole very deeply excavated; the inner furrow wide; the outer narrow and placed almost beneath the edge. The oblique depression on the second segment is wide, moderately deep, shining and impunctate; sutural articulation shallow, curved, impunctate; the apical branch almost obsolete; the furrow on the next segment is shallow and not very distinct; ventral apical segment ploughshare-shaped. Wings longer than the body; cubital nervure curved upwards at the base. Legs stout, pilose.

The ovipositor, long as it is, is hardly so long as in the Japanese *Bracon penetrator* Smith (*Proc. Zool. Soc.*, 1877, p. 413, pl. xliv., fig. 1). Smith, it may be added, figures and describes from Bogota an ichneumon, *Dolichomitus longicauda* (*l.c.*, p. 412, pl. xliv., fig. 2 and 2*a*), which has the body from 9—11 lines, and the ovipositor from 3½—6½ inches in length.

EVANIIDÆ.

GASTERUPTION ORIENTALE, *sp. nov.*

Nigrum, thorace, basique coxarum posticarum, rufis; thorace rugoso; capite laevo, albo-argenteo piloso; alis hyalinis. Long. 15 mm.

Hab. Barrackpore, Bengal (*G. A. J. Rothney*).

Antennæ not much longer than the thorax, stout; the third joint a little longer than the fourth, which is almost of the length of the fifth. Head smooth, impunctate; the face closely covered with a short silvery pile; behind the eyes bearing (but not above) a scattered pubesence, longer and more bristly than that on the face, hinder ocelli separated by about the length of the third antennal joint, and by a less distance from the eyes, which are distant from the base of the mandibles by about the length of the second antennal joint. Prosternum bearing long, dense, silvery hair; prothorax punctured in front. Meso- and metathorax rugosely punctured, running laterally into reticulations; sparsely covered with glistening white hair; median segment transversely rugosely reticulated; scutellum and metanotum black; the latter densely covered with white hair. Abdomen covered (especially laterally) with a depressed white pile; the second and third segments dull red above. Hind coxæ transversely striolated (but not strongly), punctured at the base. Hinder tibiæ with a white spot on the inner side above the middle; metatarsus a little longer than the other joints united. Inner discoidal cellules separated.

This is the first species of *Gasteruption* described from the oriental region.

AMPULEX RUFICOLLIS, *sp. nov.*

Niger, thorace rufo, metanoti medio nigro; mandibulis rufo-flavis; pedibus anterioribus ex parte rufis; alis hyalinis, fusco fasciatis. Long. 7 mm.

Hab. Gibraltar (*J. J. Walker*, R.N.).

Head semi-opaque, closely punctured; the carinate face transversely striated; almost bare, except a fringe of white hair over the mouth, which is testaceous. Antennæ bearing a sparse microscopic pile; the scape and the middle joints beneath rufous; the third joint twice the length of the fourth. Prothorax finely rugose; mesonotum obscurely punctured; parapsidal furrows distinct; scutellum obsoletely punctured; mesopleuræ closely punctured, striolated in front; the sternum covered with long white hair; metanotum with a central and three lateral keels; reticulated, the sides irregularly striolated; median segment semi-perpendicular, transversely striated, thickly covered with white hair. Abdomen shining, impunctate, the apex thickly covered with silvery white pubescence. The anterior coxæ, trochanters, and the femora, tibiæ and tarsi in front, the four posterior trochanters, and the middle femora in front are reddish ; the front femora are only black in the middle behind. The wings are very clear hyaline ; the cloud extends from the base of the stigma to the end of the third cubital cellule. The hind coxæ are densely covered with silvery pubescence.

The only genera in which this species can be placed are *Ampulex* and *Dolichurus.* Comparing it with the Indian species of *Ampulex*, the only tangible point in which it differs (that is of what might be regarded as of generic value) is that the petiole is thicker and curves more upwards ; but as there is some variation in this in the known species of *Ampulex*, this can hardly be considered of much importance. There is also one cubital cellule less, the first transverse cubital nervure being obliterated. Also in this respect the oriental species are said to vary in this nervure being occasionally faint. In the form of the abdomen it probably more resembles *Dolichurus* ; but in that genus the first recurrent nervure is received in the second cubital cellule. As in *Ampulex*, there is a tooth towards the middle of the claw. In the neuration of the wings I may add it agrees with the genus *Rhinopsis*, West. (an American genus). A careful comparison of it with a Central American species of *Rhinopsis* does not show any appreciable generic difference ; and if the neuration of *A. ruficollis* be normal, *i.e.*, if there are only two transverse cubital nervures, I do not see how it can be separated from *Rhinopsis*, and must, in fact, be regarded as pertaining to that genus, unless, indeed, the difference in the neuration between the latter and *Ampulex* be not regarded as of generic importance, in which case the two may be united.

It is, however, worthy of note that this and the only described European species of *Ampulex* have only two transverse cubital nervures as in *Rhinopsis.* Further, they differ in being smaller, and in the bodies not being metallic green or blue as in the species which have usually been regarded as typical of *Ampulex*, *e.g.*, A. *compressa*, and *A. angusticollis*. They are, indeed, so unlike that it is probable that an examination of all the species of *Rhinopsis* might reveal some other generic distinction besides the difference in the neuration, in which case the name *Ampulex* would be retained for the European species and for *Rhinopsis* (which must, in this case, be regarded as a synonym of *Ampulex*), while a new name would be required for the large metallic exotic species (*compressa*, &c.).

The only known European species of *Ampulex* is *A. fasciata*, Jurine (Nouv. Méth. d. Class. d. Hym., pl. xiv., supp.) = *europæa*, Giraud (Verh. z.-b. Ges., Wien, 1858, p. 411). This is totally black and differs otherwise in many respects from *A. ruficollis*.

GORYTES TRICHIOSOMA, *sp. nov.*

Niger, dense longe hirtus; punctatus, apice metanoti reticulato; alis fusco-hyalinis. Long. 12—13 mm.

Hab. New Zealand, Greymouth, (*Helms*).

The hair on the head and thorax is fuscous-black, long and rather dense; on the base of the abdomen it is equally long, but sparser; the hair on the rest of the abdomen is shorter and thicker. Head and thorax closely and distinctly punctured, shining; the posterior part of the mesopleuræ almost impunctate; there is a large, somewhat triangular impunctate space at the base of the metanotum, the rest of the metanotum being irregularly rugose, running into reticulations at the apex. Abdomen semi-sessile; shining; the petiole depressed in the centre at the base; the basal three-fourths with an oblique slope, the apex on a level with the second segment. There is a shallow, but distinct, furrow at the base of the latter, this furrow being irregularly crenulated. Apical segment acutely triangular, punctured like the other segments and not differing from them. Antennæ stout, as long as the abdomen; the scape bearing moderately long, black hair; the flagellum a microscopic down; the third joint is a little shorter than the fourth. Wings hyaline at the base, the rest fuscous or fuscous-black, sometimes with a violacious tinge; the stigma and nervures deep black; the first submedian nervure interstitial; the first transverse cubital nervure received in the basal third of the cellule; the part of the cubital nervure bounded by it and the first transverse cubital being curved; the second recurrent is received somewhat behind the basal fourth; the portion of the cellule bounded by the recurrent nervures is about one-fourth longer than the top of the cellule. The third cubital cellule at the top is scarcely so long as the part bounded by the recurrent nervures; the third transverse cubital nervure is more or less curved at the bottom. Submedian cellule in posterior wings appendiculated, *i.e.*, not reaching to the end of the externo-median nervures, and before the origin of the cubital nervure = *Gorytes sensu str.* Tibiæ and tarsi densely covered with a greyish pubescence; the femora sparsely with soft black hairs.

Gorytes carbonarius, Smith (Cat. Hymen. Ins. IV. p. 366), also from New Zealand, can hardly be the species I have described, for the pubescence is said to be "thin," the metathorax "smooth," &c.

CRABO CORA, *sp. nov.*

Niger, apice femorum anteriorum, tibiis tarsisque anterioribus, articulis 2—3 tarsorum posticorum, tegulisque, flavis, alis fere hyalinis. ♂. Long. 9—10 mm.

Hab. Greymouth, New Zealand (*Helms*).

Antennæ black, the middle joints inclining to fulvous beneath; covered with a microscopic pile; joint two one-fourth longer than the third; curved, thickened, and produced at the apex; the third with the apical half considerably thickened and produced, and a little shorter than the fourth, which is thicker and still more produced at the apex; the fifth narrowed at the base and nearly as long as the fourth; the sixth narrowed at the basal fourth and obliquely thickened towards the apex, which is oblique and produced on the lower side; the other joints normal. Head wider than the thorax, semi-opaque, finely and closely punctured; a wide, shallow furrow runs down from the ocelli; the front laterally, and at the middle on the apex, and the clypeus, densely covered with silvery hair. Thorax semi-opaque, finely and closely punctured; the sternum and pleuræ and apex of metathorax sparsely covered with white hairs; the metanotum almost impunctate; the centre with a deep and wide channel, which becomes wider and deeper towards the apex. Petiole half the length of the abdomen; the apex clavate; abdominal segments pale at their junction; the apical segments densely covered with long white hairs, the apical segments impunctate, truncated at the apex. The apical joint of the two hinder tarsi is black; the metatarsus is black, and the four anterior tibiæ are more or less black behind; the hind spurs are black. The tubercles and tegulæ are yellow; the scape may be more or less yellow beneath. Pronotum raised above the base of the mesonotum; this raised part depressed in the middle in front and with a distinct margin on either side of this central depression.

TACHYTES HELMSI, *sp. nov.*

Niger, opacus, breviter, argenteo pilosus; tegulis piceis; alis fusco-violaceo-hyalinis. ♀. Long. 9 mm.

Hab. Greymouth, New Zealand (*Helms.*).

Antennæ stout, as long as the thorax, densely microscopically pilose; the third joint more than twice the length of the second and about one-fourth longer than the fourth. Head covered with dull greyish hair; clypeus and sides of the front with silvery pubescence; eyes converging at the top and separated by more than twice the length of the third antennal joint; a ∩-shaped depression on the vertex, which has no dilatations, nor has the front; clypeus broadly rounded, almost transverse at the apex. The silvery white hair on the thorax is moderately thick and long; the median segment is depressed in the centre. Abdomen with the segments brownish-white at their junction and bearing a fringe of silvery hair, which is especially thick laterally; pygidial area densely covered with bristly silvery hair; the apex almost transverse, projecting laterally into a pale tubercle. Legs densely covered with silvery hair; the bristles pale; the apex of fore tarsi dull rufous; tibiæ sparsely spinose. The second recurrent nervure is received a little beyond the middle; and the two recurrent nervures are separated by a little shorter space than the length of the second cubital cellule at the top; the second cubital cellule being there slightly shorter than the third. This species belongs to the genus *Tachysphex* (Kohl).

A survey of the genus Cypræa (Linn.), its Nomenclature, Geographical Distribution, and Distinctive Affinities; with descriptions of two new species, and several varieties. By James Cosmo Melvill, M.A., F.L.S.

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CYPRÆA, or more classically Cypria, is derived from one of the many attributes of Aphrodité, owing, doubtless, to her worship not only having been inaugurated, but for long years principally centralized, in Cyprus, then a luxuriant and smiling island, teeming with industrial wealth.[a]

Horace addresses her as "Diva potens Cypri,"[b] and Tibullus, when apostrophizing the goddess thus:

"Et faveas conchâ, Cypria, vecta tuâ,"[c]

surely pictured her but lately risen from the foam, reposing in some glassy Nautilus shell, her most seemly fairy sea-chariot. Allowance must always be made for mythical as well as poetical license; yet it is almost impossible to comprehend how some old writers, as Rondelet, the famous chemist and natural historian of Montpelier, can have supposed the Cowry to have been the dreaded *Echeneis*,[d] or *Remora*, a sucking fish which, on the authority of Herodotus, so clogged the course of Periander's warships at the instance of Venus, as to stay the meditated execution of the youths of Corcyra, and hence, in gratitude to the engine that averted this wholesale massacre, the title of *Cypria*, or *Concha Venerea* was bestowed. Certainly this is a primæval instance of Beauty and the Beast, of earlier date probably than the well-known legend, but we argue that the Cowry

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[a] Æs Cyprium = κύπρον, copper. Plin. 34, § 20.
[b] Hor. Od. i. 3. 1.
[c] Tibullus iii. 3, 4.
[d] *Cf.* Pliny N. H. 9, 25.

cannot have been the Beast, far more likely the gigantic Calamary, or Octopus, was intended, of which specimens of almost Titanic size abound in deep sea caverns in Sicily and the rocky Calabrian shore.

Granted the name arose on account of the grace of form of these shells, it is a matter of some little difficulty to conjecture exactly the time *when* it was bestowed upon the genus exclusively. Linnæus probably did not coin it himself; he was fond of using ancient appellations, yet no mention can be found of it in Pliny or Aristotle; indeed, as late as the time of Rumphius at the end of the seventeenth century, it was termed PORCELLANA, or ERYTHRÆA;[a] it is probable, however, that about that date, or certainly not later than 1740, CYPRÆA usurped these old titles, and it was, at all events, finally fixed, in strict accordance with the revised canons of priority by Linnæus (xii. ed. "Systema Naturæ") in the year 1767.

Now, however, *Cypræa* is, perhaps, the most conspicuous and generally known of all Mollusca. Although we have only one small representative of the family on our own coasts, the variable little Nun Cowry, (*C.* [*Trivia*] *Europæa*, *Montagu*), certain of the Tropical species are imported very plentifully. No sandal-wood box, forwarded from the East by native collectors, who abound at Singapore, Amboyna, and Ceylon, but is certain to contain at least twenty of the most ubiquitous and showy of the smaller kinds; whilst of the larger, *C. Mauritiana*, *pantherina*, *talpa*, and *tigris* are well known as ornaments on many a cottage mantel-shelf. Owing to the protection the surface of the shell receives through its being more or less covered by the mantle of the

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[a] *C. pantherina* comes from the Red Sea, also some other beautiful species. "E. rubro lucida concha mari," Tibullus ii. 4, 30, and *cf.* Prop. iii. 11, 16. The *Meleagrina*, or Pearl oyster, may however be more probably intended in these allusions—as fisheries for the purpose are known to have been carried on in the "Mare Erythræum."

mollusc during life, a specimen in inferior condition is the exception, not the rule, and this fact adds to their abundance and, perhaps, popularity.

(I.) *Uses, commercial or otherwise.*—The Money Cowry (*C. moneta* L.) is of commercial interest, from being used as a substitute for coin, especially in Africa and certain parts of India. This is a very abundantly distributed species, of less beauty either of form or colour than many of its kindred, but of very marked individuality. It is collected plentifully throughout the Eastern Islands, especially in the lagoons of the low-lying Laccadives and Maldives, in the Indian Ocean. About 3,200 Cowries equal a rupee in value. From a very remote period we read of these shells, or some allied species, being used for various purposes. The term Cowrie, or Gowrie, is derived from the Greek χοῖρος, a little pig; and the χοιρίνη, according to Liddell and Scott, was a 'small sea mussel, probably the *porcelain shell*,' which was used by the Athenian dicasts in voting:—so quoted by Aristophanes,

οὐ χοιρινῶν ὄζων, ἀλλὰ σπονδῶν.[a]

and, again,

ἢ δῆτα λίθον με ποίησον ἐφ' οὗ
τὰς χοιρίνας ἀριθμοῦσιν.[b]

Following the example of the Greeks, the Romans termed these little shells *porci* or *porculi*, whilst the French nowadays term them pou de mer; and in the word *porcelain* we can also trace the same derivation.

Some of the larger species, too, especially *C. tigris* and *Arabica*, are used for ornamental shell work. The latter, when decorticated with acid, has a fine lilac surface; the Lord's Prayer, and other inscriptions I have seen carved on these species; also heads, as on the true Cameo shells, *Strombus* or *Cassis*, but the effect is usually inferior, the Cowry shells being hardly massive enough for this purpose.

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[a] Aristoph. Eq. 1332.
[b] Aristoph. Vespæ. 333, 334.

(II.) *Fossil Forms.*—The Cowries first appear in the Cretaceous and Tertiary Periods: there are between ninety and a hundred fossil forms, mostly smaller than many of their recent congeners. Dr. F. Jousseaume published, some four years ago, a proposed subdivision of the genus, taking into consideration the extinct as well as the recent species;—a very laudable attempt, but we can hardly agree with him in considering it necessary to propose no less than thirty-six genera, most of them new, for their reception! His *Zoila*, for instance, formed for *C. Scottii*, *Thersites*, and *marginata*, his *Mauxiena*, for *C. Mauritiana*, and *Trona*, for *C. stercoraria* and *venusta*, should surely be all included as very nearly allied, in *one* section of the genus; and the same might be said for three more of his so-called genera *Luria*, *Zonaria*, and *Adusta*, since *spadicea*, *physis*, and *onyx*, severally representatives of these three, are of extremely near affinity. And other instances might be adduced. I am very pleased, however, to find Dr. Jousseaume and myself agreeing in several particulars, and, as I had not the opportunity of seeing his interesting article until I had drawn up the annexed list of the approximate relations of the species to each other, my conclusions have been in every way independent. He isolates *C. umbilicata*, *C. tessellata*, and *C. Childreni*, allies *C. stercoraria* to *C. venusta*, but includes *C. lynx* and *mappa* with the *tigris* section, called by him *Vulgusella*, which I am unable to do. *C. mus* and *leucostoma*, which would appear survivals of an otherwise extinct group, he places in the genus *Gisortia*, the type being the large fossil *Ovula gisortiana* (Val.). The puny little *C. Adamsonii* (Gray), again, is the only recent representative of some attractive fossil forms, of which *C. elegans* and *C. cancellata* (Swainson) may be considered the types, peculiar from the surface being covered with raised reticulated striæ.

(III.) *Catalogues and monographs of the Genus.*—Besides the monograph of Dr. Jousseaume just alluded to, and which was published in the *Bulletin de la Soc. Zoologique de France*, 1884, the following catalogues, treatises, and monographs, which include descriptions of *Cypræa* and *Trivia*, exist:—

Linné, C. Systema Naturæ (Ed. xii.), 1767.

Martini. Conchylien-Cabinet, Vol I., 1769.

Perry, George. Conchology, 1811. (Five plates of the 61 devoted to Cypræa).

Dillwyn. Descr. Catalogue of Recent Shells, 1817.

Lamarck. Histoire naturelle d'Animaux sans Vertèbres, Vol. VII., Ed. i., 1822, and Ed. ii., augm. par Deshayes et Milne Edwards, Vol. X., 1844.

Gray, Dr. John Edward, F.R.S. Zoological Journal, 1824.

Wood, W. Index Testaceologicus, 1828.

Sowerby, G. B. (the elder). Conchological Illustrations, 1837.

Deshayes, G. P. Encycl. Méthod., Vol. III.

Jay, J. C. Catalogue of Shells in his Cabinet, 4 Editions. New York, 1835-52.

Hanley, Sylvanus. Ipsa Linnæi Conchylia, 1855.

Kiener, L. C. Coquilles Vivantes, about 1840.

Catlow and Reeve. The Conchologist's Nomenclator, 1845.

Reeve, Lovell. Conchologia Iconica, Vol. III, 1845.

Adams, H. & A. Genera of Recent Mollusca, 1858.

Sowerby, G. B. Thesaurus Conchyliorum, 1870. (Vol. III. pars).

Weinkauff, H. C., in Küster's Conchylien-Cabinet, 1881.

Roberts, S. Raymond. Monograph of the Family Cypræidæ, in Tryon, Man. Conch., Philadelphia, 1885; also Catalogue of Porcellanidæ, 1869; Amer. Jour. Conch. V.

* Paetel, Fr. Conchylien-Sammlung, 1887, Berlin. Catalogue of all hitherto described recent Shells, 6 parts, all published.

(IV.) *Systematic position.*—The Family *Cypræidæ* is placed amongst the *Rostriferous* Section of Gasteropoda Prosobranchiata, following the *Strombidæ* and *Terebellinæ*, and immediately preceding the *Ovulidæ* (*Amphiperasidæ*, Adams) and *Pedicularidæ*, this last curious little genus of somewhat distorted shells, living imbedded in corals.

With *Ovula* (Brug.) there is, of course, the most near relationship of all other genera; but no *spire* exists in the true Egg-shells at any period of growth, the *colour* is mostly pure white porcellanous, sometimes pink, yellow, or lilac, *extremities* more or less beaked, *outer lip* often toothed or plicate, *inner lip* always smooth. *Head* of the animal furnished with a *contractile Snout.*

The *Ovulæ* appear first in the Chalk, but are rare, and often confounded with *Cpyræa.* About fifty-five recent species are known.

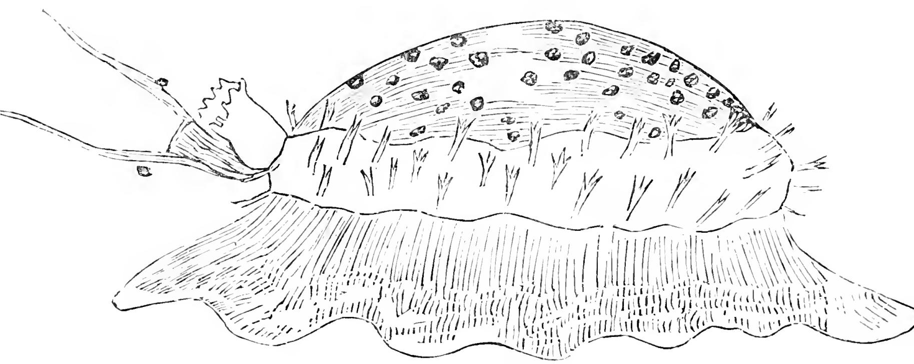
The similitude of the family to certain forms of *Cassis*, e.g. *C. rufa* (L.) and *C. testiculus* (L.), in the toothed lip, is but superficial. Mr. Stutchbury separated these two species from the true Helmet shells, under the name *Cypræacassis*, but they are now included in the subgenus *Cassidea* (Brug.).

We are indebted for the accepted classification of the Mollusca, mainly to the researches of the late Dr. Gray, of the British Museum, Dr. Forbes, Mr. S. P. Woodward, author of that admirable work, "*Recent and Fossil Shells*," and Messrs. Henry and Arthur Adams. This classification, founded as it is on the truest scientific basis, viz., the drawing of the characters not so much from the shell as its

* NOTE.—Owing to the lamented death of Herr F. Paetel last October, at the age of 76, it is to be feared that this useful Catalogue may not be completed. Only six parts have been issued, down to the Ampullaridæ. We have also to regret the demise of Mr. G. W. Tryon, junr., of Philadelphia, author of the yet incomplete "Manual of Conchology," and other valuable works.

inhabitant, is full of inherent strength, and will probably hold its own, as regards its most salient features, against any proposed changes.

(V.) *Animal.*—The *Animal* has been figured by Messrs. Adams, and by Chenu, "Manuel de Conchyliologie," Vol. I., f. 7. In this latter a coloured representation of C. moneta is given, the *tentacles* are stout and gradually tapering, *eyes*



Animal of Cypræa tigris (Linn.).

situated on slight excrescences about one quarter the distance from the head, *mantle* fastened into two folds, meeting over the back of the shell at the dorsal sinus, and likewise ornamented with forked filaments, papillæ, or verrucæ, and sometimes they are smooth—the mantle is furnished also with a *siphon*, which is often fringed. The *foot* is large, and simple, fastened at either end, frequently contracted in front. *Head* obtuse, furnished with a contractile snout, or rostrum. No *operculum*. *Lingual Riband* long, with seven series of teeth

Lingual Dentition of C. tigris (L.).

(3, 1, 3). According to Adams, each row is composed of "one broad, quadrate, uncinated axile tooth, flanked on each side by three hooked laterals; outer lateral teeth conical, entire or toothed." The animals are often resplendent with gaudy coloration, and white, yellow, vermilion, and rose are mentioned as predominant.

(VI.) *Growth and recuperative power.*—The *Young Shell* differs extremely from the mature, it is Bulla-shaped, thin, with a distinct spire often covered with a fine epidermis; the pattern and markings, as a rule, blurred and hardly commenced. The whole of plate xxvii. of Reeve, Conch. Icon., is taken up with figures of Cowries in this state, and is worth consulting.

During growth, another phase is entered upon, the shell somewhat solidifies, the lip and columella thicken and show more development, the dentition commences, and the pattern, usually in triangular or zigzag flames and waves, asserts itself. The *third*, or concluding period, is when the calcifying process of the dorsal lobes of the mantle applies its energies to the base, teeth, and sides, covering the whole shell with porcellanous enamel, and completing the now recognisable design.

As regards the unique power attributed to this genus of shells, by one observer only, Lieut. J. B. Hankey, R.N. (whose correspondence with Mr. Lovell Reeve on the subject may be found in Conch. Icon. Cyp. pl. i. Letter-press), viz., that he had been "in more than one instance an eyewitness" of a Cowry dissolving and decomposing its own shell as a preliminary to enlarging its borders, with some solvent fluid secreted in its mantle; far be it from me to cast a shadow of doubt on this officer's veracity or powers of discrimination, yet it does appear strange that no other observer has noticed this phenomenon, more especially as there are at this time five Naturalists at least in the Tropics to one in Lieut. Hankey's day, now nearly fifty years ago. This Naturalist adds that when the Cowry had virtually become naked and defenceless, in a short time a thin layer, of the frail consistency of shell-lac, began to cover it, and it assumed the form of a Cymba, of the family Volutidæ, but owing to the extrême delicacy of the organization, he could not preserve any specimens.

(VII.) *Generic and subgeneric divisions, hitherto adopted.*—Dr. Gray's subdivision of the genus, adopted with some modifications by Messrs. Adams, 1858, in their "Genus of Recent Mollusca," Vol I., p. 263, is as follows:—

CYPRÆA (L.).

Shell ovately cylindrical, polished; spire obsolete, or concealed by enamel; aperture narrow, linear, inner lip denticulated; outer lip greatly inflected, denticulate or crenate.

Type C. talpa (L.). 32 sp.

ARICIA (Gray).

Shell ovate, dorsally gibbous, flattened at the base, the sides thickened and dilated, polished; spire concealed; aperture narrow, linear; inner lip gently expanded and callous, dentato-lirate; outer lip dilated, flattened and callous, dentato-lirate.

Type A. annulus (L.). 21 sp.

LUPONIA (Gray).[a]

Shell ovately pyriform, ventricose, smooth, polished; spire concealed, often depressed; aperture narrow, linear, inner lip plicato-dentate, the plaits often obsolete posteriorly; outer lip inflexed and crenate.

Types L. tigris (L.), L. Algoensis (Gray). 59 sp.

[a] Of L. Edentula (Sowb.) Mr. Roberts has made a genus GASKOINIA, the only characteristic of which is that the teeth are obsolete. As, however, some specimens are slightly toothed, I see no necessity for maintaining this name even as a subdivision.

NARIA (Gray).

Front of columella narrow, dilated into a sharp toothed ridge, shell smooth.

Type N. irrorata (Soland.). 1 sp.

CYPRÆOVULA (Gray).

Shell oval, ventricose, surface covered with elevated striæ, aperture narrow, linear; inner lip denticulated, outer lip inflected and transversely striated.

Two species—C. capensis (Gray), C. Adamsonii (Gray).

TRIVIA (Gray).

Shell oval, rather depressed, surface covered with elevated, transverse ribs, or tubercles, spire concealed, aperture narrow, inner lip sulcated, outer lip transversly grooved.

Type T. Europæa (Mont.). 34 sp.

Subgenus PUSTULARIA (Swainson).

Back with elevated tubercles, extremities slightly produced.

Type P. pustulata (Lamk.). 4 sp.

Subgenus EPONA (H. & A. Adams).

Shell globose, back smooth, or with elevated tubercles.

Type E. cicercula (Gmel.). 4 sp.

These subdivisions are almost purely artificial, and do not always hold good. *C. carneola* (L.), for instance, has two forms, one a typical *Cypræa*, the other with flattened base, would have to be placed in *Aricia*. I am inclined to agree with Sowerby, Thes. Conch. III., in allowing merely a subgeneric rank to TRIVIA alone, and entirely ignoring all the others. In the early part of this year I received from Mr. G. B. Sowerby a shell which, while it possesses the facies, dentition, and raised striæ on the lower surface, of *Cypræovula Capensis*, has the form as well as markings of *Luponia Algoensis* (these being Dr. Gray's types of his two genera), and a new and most important link in the chain of connection is thereby shown. I propose to call this *C. amphithales*, and am convinced it is specifically distinct, having seen several specimens, all alike, though mostly a little worn on the dorsal surface, which is, however, always *smooth*, specimens in fine condition having been lately sent home by Mr. Bairstow. As will be seen subsequently, I append to this paper a list of all the known kinds, with their synonyms and varieties, devised upon a circular system; that is to say, although the species are necessarily arranged in what appears at first sight a tabular form—from Nos. 1 to 189—I mean that No. 189 will bear the nearest link to 188 on one hand and to No. 1 on the other, and so on. The extremes that according to this circular catalogue are thus placed in juxtaposition, *C. leucodon* (Brod.) and *C. Valentia* (Perry), or *princeps* (Gray) are, to quote a very interesting writer,[a] "probably the tips of the branches of the Conchological *stammbaum* or genealogical tree, which may have reached the limit of possible development in their own direction." Both of these will be discussed more fully in another paragraph, it will suffice to say at present that there would seem to be some divided marks of affinity to bind them to each other, isolated as they stand in the series.

Again, the *Triviæ*, hitherto usually considered a distinct genus, are intimately connected with the *Cypræa* proper on the one hand through *T. pustulata* (Lamk.), the young of which infringes closely upon *Cypræovula Adamsonii* (Gray), and, on the other, through the numerous smooth varieties of *Trivia staphylæa* (L.), which trench upon *C. Helvola* (L.), var. *Hawaiiensis*, and the rest of the members of that section (*Erosæ*) whose marginal pitting of the sides is also found in the varieties of *staphylæa* just mentioned, e.g. *polita* (Roberts), *limacina* (Lamk.), etc.

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[a] Notes by a Field Naturalist in the Western Tropics, by the Rev. H. H. Higgins, M.A., 1877.

(VIII.) *Geographical Distribution.*—Mr. A. R. Wallace's[a] six regions are, in the subjoined table, slightly modified, especially as regards (*c*), which here must be understood to comprise Europe alone, with the whole of the Mediterranean and the Azores and Madeira; (*e*) Australia, New Zealand, Tasmania, and the Fiji Isles alone; while (*f*) becomes much the largest and most important subdivision, embracing the Red Sea, Persian Gulf, India, the East Indies, and the whole of the rest of Polynesia. The extremely wide distribution of many of the commoner species of the genus causes the above alterations to be necessary, let alone the fact that Mr. Wallace's regions were proposed by him more with a view to the inhabitants of the land than of the sea. Of about ten or eleven species the locality is altogether doubtful.

Region.	No. of Species.	Region.	No. of Species.
(*a*) *Nearctic*; *i.e.*, United States & Canadian Coasts, Atlantic, and Pacific.	8	(*d*) *Ethiopian*; including Madagascar and the Mascarus Islands in the Pacific, C. de Verdes and Canaries in the N. Atlantic, also St. Helena and Ascension Isles in S. Atlantic.	32
(*b*) *Neotropical*; *i.e.*, Mexico, and Central American Coasts, Gallapagos Isles, W. Indies and South America, Atlantic and Pacific.	28	(*e*) *Australian*; here signifying Australia, Tasmania, New Zealand, and the Fiji Isles.	48
(*c*) *Palæarctic*; here simply including European Seas proper, with both shores of the Mediterranean, the Madeiras, and Azores.	8	(*f*) *Oriental*; embracing Chinese Seas and Japanese, E. Indies, Polynesia, Persian Gulf, and Red Sea, also Indian Seas and Ceylon.	105

[a] "Geographical Distribution of Animals," by A. R. Wallace, F.R.S., &c. 2 vols., 1876.

In Polynesia alone Mr. Andrew Garrett[a] found no less than 75 species himself, with many varieties. His valuable paper is to be found in the *Journal of Conchology*, Vol. II., 1879, pp. 165 sqq. And in Moreton Bay, Queensland, Mr. Brazier mentions Mr. Coxen and himself discovering 27 sp.—*J. of Conch.*, 1879, p. 318. The same collector also enumerates (*Proc. Zool. Soc.* 1872, pp. 82-86) 39 species as occurring on the shores of New South Wales. The late Mr. G. F. Angas, who likewise collected largely in Australia, published a list of Cypræa at various times in *Proc. Zool. Soc.* 1865-77, from that region, especially from the neighbourhood of Port Jackson, in which about the same number are reported. Again, in the list of Mollusca collected by Dr. Anderson, F.R.S., Superintendent of the Indian Museum, Calcutta, in the islands of the Mergui Archipelago and coasts of Tennasserim, 16 Cypræa are mentioned by Prof. Von Martens (*Journ. Linn. Soc. Zool.*, Vol. XXI., p. 185 sqq.), 1888. Of these, *C. Saulæ* (*Gaskoin*) from Elphinstone Island, is the only rarity. Several tropical species, *e.g.* *lynx*, *Arabica*, *vitellus* occur in the Bay of Yeddo, Japan (Lischke). Swinhoe detected eight common species only at Formosa, while Jickeli (*J. B. Mal. Ges.* XI.) gives 30 species as occurring in the Red Sea. Mr. R. Rossiter, exploring in New Caledonia,[b] mentions (*Proc. Linn. Soc. N. S. W.* VI., pp. 817, 832) 60 species on those shores, whilst Mr. Philip P. Carpenter only noticed 7 sp. at Panama (*Proc. Zool. Soc.*, 1863).

The figures above quoted must be taken with all reserve, for there is every probability further researches in (*d*) and (*e*) will raise the figures nearer those attained by (*f*).

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[a] News has only lately been received of the death of this celebrated conchologist after a lingering illness, aged 65 years, at his residence at Huahine, Society Islands. Mr. Garrett contributed several very valuable papers to various learned Societies on the distribution of certain genera of Mollusca in the Polynesian Islands, and had amassed a very large collection, one half of which (4,000 species) had been gathered by his own hands.

[b] Also *cf.* Crosse et Fischer, Les Mollusques de Nouvelle Caledonie.

One cannot help being struck, however, with the poverty of the new world compared with the old; and I believe that in many other marine genera of shells, *e.g.*, *Conus* and *Mitra*, the same proportionate inequality would occur, especially in the Neotropical South Atlantic Coasts. *Conus cedo nulli* (L.), however, is a native of West Indies, and two of the recent species of *Pleurotomaria*, which make up for many deficiencies of lesser note.

When comparing the nearly allied genus *Ovula*,[a] the species of which are about fifty-five in number, the preponderance of those found in (*f.*) is almost overwhelming.

	No. of Species.
(a) Nearctic	3
(b) Neotropical	5
(c) Palæarctic	3
(d) Ethiopian	7
(e) Australian	4
(f) Oriental	33

The *localities* in which the tropical Cowries and *Ovulidæ* are found are mainly amongst coral reefs, or in the sands near shelving rocks: while certain of the *Ovulidæ* are attached to gorgonias, whose colours they often assimilate: they all move slowly, and are extremely susceptible of fear, feeding mainly upon coral zoophytes. But few inhabit the deep sea: only 13 species, mostly single individuals, are recorded as being found during the "Challenger Expedition," 1873-1876. (*Rep. Expl. Challeng.*, Vol. XV., Zoology, p. 421, sqq.)

(IX.) *Total Number of Species.*—Paetel in his last catalogue (1887) enumerates 223 of *Cypræa* and *Trivia* combined, but various errata and duplications have to be expunged, reducing the total to 181. To this add eight, four being good species relegated by him to varietal rank, and four

[a] Ovula must be taken here in a collective sense, as embracing Volva and Cyphoma (both of Bolten), Simnia (Risso), and Calpurnus (Montfort).

newly described *C. Hungerfordii* (*Sowb.*), *C. Rashleighana* (*Melv*), *C. amphithales* (*Melv.*), and *C. caput draconis* (*Melv.*) which brings up the total to 189. In the collection now exhibited there are about 170 species, besides varieties, and several of these are type shells, notably some of those formerly in the collection of Mr. J. S. Gaskoin, who for years made a special study of the Cowries, and whose whole series was acquired by Mr. T. Lombe Taylor, of Starston Hall, Norfolk, the dispersion of whose vast stores in 1879 made an unusual stir in the conchological world.

(X.) *Prominence and isolation of some Species.*—In no other genus of shells do certain members of it take so distinctive a place; there are, for instance, six kinds which add the charms of being almost or quite unique to their beauty and unusual forms. Amongst these first to be noted is:

Cypræa leucodon (*Broderip*), described in 1828, Reeve C. I. f. 23, and *cf.* Sowb. Thes. Conch., pl. iv., f. 19, 20, a large handsome species between three and four inches in length, tawny with a few large round white spots, base tawny, teeth very strong, deeply sulcated, white.

No locality known. This has been unique in the National Collection for sixty years, and was considered by Mr. Lovell Reeve to be, with *C. princeps*, the most valuable of all yet discovered shells. A slight affinity in shape with this latter, and in the arrangement of the teeth with *C. sulcidentata* (Gray)[a] may be traced, but it does not very nearly approach any known species—recent or fossil, nor could it be an undue development of any other kind.

C. princeps (Gray).—This, originally described by Mr. Perry[b] as *C. Valentia*, which name has priority, from the

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[a] C. sulcidentata (Gray) is connected with C. arenosa (L.) and ventriculus (L.), but differs from all except leucodon (Brod.), in its deeply channelled tooth-grooves. It is a shell of some rarity.

[b] Mr. George Perry in 1811 published a large folio volume, in which many

first known specimen having been sold by Mr. Humphrey to Lord Valentia, a patron of science in the last century, is even more extraordinary a shell than the last. Figured by Perry, Conch., pl. xxiii., f. 2; by Sowerby, Thes. Conch., pl. i., f. 1, 2; and by Reeve, Conch. Icon. pl. vi., f. 20. Its length is very nearly four inches. It is yellowish, tinged with purplish rose, painted over the dorsal surface with yellowish brown markings, clouded on each side with a large darker blotch, at each extremity there are three rows of brown lines, sides with blue and brown spots. Base white, teeth also shining white.

Recent discoveries have resulted in five specimens, all exactly similar, in addition to the original shell in the National Collection. These six are disposed as follows:—

2 in the National Collection, South Kensington.
1 in Coll. Zool. Soc., Amsterdam.
1 in Coll. Miss Saul, Bow Lodge, London, N.
1 in Coll. Dr. Cox, Sydney, N. S. W. Dredged off New Guinea Coast.
1 in Coll.—uncertain.

The original specimen was called the "Brindled Cowry of the Persian Gulf," in old Humphrey's handwriting, but no other specimens have been known to come from that region, I believe. Mr. Perry mentions Amboyna, but that place must always be taken with some reserve, being a trading centre where such things are imported from a distance.

C. guttata (Gray).—This shell evidently belongs to the *Lamarkii* and *erosa* section of Cypræa, and yet there are

shells were delineated and described for the first time. Unfortunately he does not appear to have taken the trouble to consult previous authors, hence his writings abound with duplicate names, glaring errors, description of young shells as separate species, and the like. He has fallen under the lash of subsequent writers, especially Messrs. Sowerby and Reeve, who ignore all his descriptions, but in justice to him and to the law of priority, where his species can be deciphered, many of the paintings being very fanciful, it is only right to attach his names—*C. princeps* (Gray.), *nebulosa* (Kien.), *turdus* (Lamk.), and *melanostoma* (Leathes), thus become *Valentia*, *Surinamensis*, *ovata*, and *camelopardalis* (all of Perry).

no closely connecting links. I am inclined to think C. *fuscodentata* and *capensis* may not be so far removed from it after all; and in *C. bicallosa* (Gray) with its large varieties, *ingloria* and *Aubreyana*, a slight resemblance may be traced.

The length is about 2½ inches. Shell yellow-fawn, of light texture, sprinkled with several large and small round white spots over the dorsal surface; on the base and over the sides the teeth extend, which are bright orange, and ridged.

The localities given are China, N. S. Wales, Red Sea, and New Britain, but I doubt these being substantiated, except, perhaps, the first and last, this being recorded by Mr. Hobson (1879). It is probable, from its thinness, that it is a deep water species.

The specimens known are seven, or, at most, eight in number, disposed as follow:—

1 in National Collection (not very good), *cf.* Reeve, Conch. Icon., pl. viii., f. 30.

2 in Miss Saul's Collection.

1 formerly in Dr. Prevost's Collection, Alençon (subsequently in M. Grasset's, of Algiers, and now in the museum, Dijon, France).

1 in the Leyden Museum.

1 in Mr. J.C. Melvill's Collection, Prestwich (Fig. 7). This specimen is one of the finest known, and was formerly in the collection of Mr. Hugh Owen, from whom it was procured through the agency of Mr. R. Damon, of Weymouth. It is the type figured by Sowerby. (*Thes. Conchyl.*, pl. xvii., f. 104, 105).

1 in Mus. Acad. Scient., Philadelphia, presented by Dr. T. B. Wilson, a fine specimen.

I believe Herr Paetel, of Berlin, also possesses one.

N.B.—This species has been long known. Martini (1769) figured it in his "Conchylien-Cabinet," Vol. I.

Some authors imagine *C. Jenningsia* (Perry) to be a synonym, but neither the figure (pl. xix., f. 4) nor the description bear out this theory. I will refer to this again under the head of "doubtful species."

C. Barclayi (Reeve).—A small, deep water form. Length a little over 1 inch. It is white, sprinkled over with tawny yellow, the extremities and unusually developed teeth, quite unlike any other species, bright yellow-orange, the labial teeth overlapping the base.

Sir David Barclay, Bart., a most experienced Conchologist, and resident for many years at the Mauritius, dredged this off I. Diego Garcia. He allowed it to pass from his hands, thinking that more would reward his research, but, to his disappointment, another specimen has not turned up. The original and unique shell adorns the collection of Miss Saul.

The other two extremely scarce species are *C. Broderipii* (Gray) and *C. venusta* (Sowb.). Reference will shortly be made in another place to the former of these, and the latter, whilst differing in colour (being of a pale creamy fawn,) and in some other particulars from *C. stercoraria* (L.), can hardly claim an isolated position in the genus. Miss Saul and Dr. Cox, of Sydney, possess the only specimens yet known to exist.

C. aurantium (Martyn).—The far-famed Orange Cowry, termed by Chemnitz the "Aurora Solandri," was for many years considered the most esteemed of the genus, as it is still by far the most conspicuous. The length of the full grown mollusc is nearly 4 inches,—shining, globose, orange, within darker, teeth bright orange, base bright white. The Fiji, Loyalty and Friendly Islands, produce this shell. It is considered the badge of Royalty amongst some of the savage tribes, hence specimens coming to this country are occasionally found to have been perforated with holes, so that they might be strung together as a necklace. The natives of these Islands now know, or more than know, their value, and two might be obtained at the marts in London for the price at which one inferior specimen could be obtained in Fiji at the present time.

Mr. Marrat considers this species is very near, if not identical with, *C. mappa.* I can hardly agree with him. The yellow teeth seem to me the only link of affinity, and I am strongly of opinion that it has no congeners in the genus.

C. testudinaria (L.) is a very isolated shell. In length about 5½ inches, oblong, narrow, whitish brown, back marked with burnt sienna—brown and black, like tortoise-shell, besprinkled, in the adult, with indented white punctures, teeth smallish, white. A common species from the East Indies, but one of the handsomest of all. No other species, excepting *C. Bregeriana*, has the peculiarity of the small white specks, but some affinity in the cylindrical shape with *C. argus* (L.) may be traced.

C. umbilicata (Sowerby).—The resemblance to *C. pantherina*, of which it was thought once to be a monstrosity, is entirely superficial. It is depressed in front, with produced extremities, the spire deeply umbilicated, teeth brownish, markings pale fawn-coloured brown. Length, nearly four inches. A species, formerly very rare, dredged abundantly and without any variation, except an occasional white variety, in Australia. (var. *alba* of Cox).

C. lynx (L.).—It may surprise some conchologists to find this spoken of as an isolated species, but in attempting an arrangement of exact affinities I have had much difficulty. The nearest relation it possesses is undoubtedly *C. Walkeri*, with which it agrees in form, and coloration of the teeth interstices. It is variable, but always known by its oblong shape, clouded bluish and brown markings, with occasionally a dash of red, base and teeth white, base often with peculiar longitudinal sharply cut angled depression, which is very characteristic, interstices between the teeth invariably bright orange red. Length normal, 1 to 1½ inch. Mr. J. M. Williams, of Liverpool, has a magnificent specimen, 3¼ long., 1¾ lat.

Native of all Eastern Seas. Abundant.

(*a*) *Williamsi* (*var. nov.*).—Base suffused with orange red, pattern on dorsal surface much blurred with fawn colour. Length 2 in., lat. 1¼. In Mr. Williams' coll. A striking colour variety.

(*b*) *Caledonica* (Crosse).—Distorted var., with extremities elongated, and unequally produced. Rare. New Caledonia. *cf.* Tryon, Man. Conch. pl. xiv. f. 98.

C. tessellata (Swb.).—Dorsal surface tawny, with three broad bands; sides squarely marked with black-brown blotches bordered with white, and two chesnut-brown spots; base pale tawny and white, banded transversely; teeth orange; mouth straight, narrow. Length 1⅛ inch. Rare. Eastern Archipelago. New Zealand has been recorded, but I doubt its occurrence there. Only very few specimens are known otherwise than in a decorticated state. Those belonging to Miss Saul and the late Mrs. De Burgh surpass all others.

C. Childreni (Gray).—Transversely ribbed throughout, pale coloured, extremities angularly expanded below. This last development does not occur in any other species. Native of Polynesia.

C. Adamsonii (Gray).—To the unique peculiarities of this species, as recent, I have already referred. As Mr. Sowerby aptly observes, young specimens of *Cypræa pustulata* (L.) are allied to this. It is a native of the Philippines and Mascarene Islands.

C. irrorata (Solander).

The prominence of the anterior columellar teeth distinguishes this species from any other, hence Dr. Gray created a new genus for it, Naria (Descr. Cat., Cyp., p. 12, 1832). Native of the Low Archipelago, Paumotus, etc. I think there are several points of connection between this somewhat isolated species and *fimbriata*, *microdon*, etc.

(XI.) *Groups of two or three in close affinity with each other, otherwise somewhat isolated.*

C. talpa (L.).

C. exusta (Sowb.).

Both these must surely have descended from a common ancestor, but the distinction is never failing, and known at once. The latter differs from the commoner and more widely distributed *talpa* in being more pyriform in shape, teeth more numerous, smaller, and somewhat immersed, aperture narrower. While *C. talpa* is found commonly in the Eastern tropics, *C. exusta* is confined to the Red Sea, but it is a great deal more than a local variety.

C. mus (L.)

C. leucostoma (Gaskoin).

The latter, which is rarer, has often been confounded with *C. mus*, indeed, it was not till 1843 that Mr. Gaskoin differentiated the two. The complete absence of teeth in the latter, the white base, and the heavier and white appearance of the shell, with one or two other distinctions of minor importance, amply distinguish them: but they are not nearly allied to any other of the genus, though a fossil form or two is rightly connected with them by M. F. Jousseaume, Natives, *C. mus* of the Mediterranean, and W. African shores., *C. leucostoma*, Arabian coasts.

C. lurida (L.).

C. pulchra (L).

C. controversa (Gray). *Isabella* (L.) var.

On the upper side these three are very similar, all being bluish-cinereous with two brown spots at either extremity. Below, however, the common *lurida* is wide-mouthed, with coarse dentition, *C. pulchra* and *controversa* have a narrower aperture, but the latter is pure white both as to the base and teeth, with the extremities yellow spotted as in its type *C. Isabella*, the former being olivaceous, with small, fine, somewhat obsolete teeth, of a reddish tint.

C. lurida is common in the Mediterranean and part of the Atlantic Ocean, *pulchra* only found in the Red Sea, and *controversa* from the East Indies and Mauritius. Mr. R. C. E. Stearns (*Proc. Ac. Phil.*, 1878, p. 399) thinks this variety distinct, and signalises it as having been found in California. Has this been confirmed?

C. Broderipii (Gray).

C. nivosa (Broderip).

C. vitellus (L.)

C. camelopardalis (Perry), *C. melanostoma* (Leathes).

The reason I call attention to this quaternion is that, while they are all very nearly allied to each other, two of them are only distinguished by characters not seen at a glance, but when seen, proving how extremes meet, while *C. Broderipii* is one of the rarest and most beautiful of known shells. It is the largest of the four, measuring over 3 inches in length, and is globose, the dorsal surface tinted rose-colour, with brown network pattern overspread. Beneath, the teeth are long and well developed. Base pinkish. Native of Madagascar.

Six specimens are known; of which—

1 in National Collection, S. Kensington.
1 formerly in Mr. Hugh Owens' Collection.
2 in Miss Saul's Collection.
2—dispositions uncertain.

C. vitellus (L.) and *C. nivosa* (Brod.).—Both with near affinities to the preceding, are yet at first sight so close to each other as to appear hardly even varieties. And yet few species are so distinct. In the common *vitellus* a widely distributed East Indian species, the pattern of pure white spots is first deposited by the mantle of the animal, and then the grey-brown colour is enamelled over, but thinly, so as not to conceal the now slightly blurred and somewhat indistinct spots. In *nivosa*, on the other hand, the grey-brown colour is first deposited, and then the next, clear cut eye-like holes are cut out, as it were, by some secreting juices; leaving them clearly defined, and there is no sign of the blurred lateral striæ, so conspicuous in *vitellus*. *C. dama* (Perry), Conch. xxiii., 3, has been supposed to be *nivosa*, and thus to claim precedence of title. But I am convinced, on examining Mr. Perry's figure, that *vitellus* was intended, for the 'hair-like marks at the sides' are not only mentioned in this description, but also delineated. Broderip's name will therefore stand. This species is very rare; found at the Mauritius. My specimen came from Mr. Lombe Taylor's collection. The dentition of both these is identical.

C. vitellus (L.) (*a*) *sarcodes* (var. nov.).—A colour variety, of pale uniform flesh colour, otherwise as in the type. Figured. Sowb. Thes. Conch., pl. vi., f. 31.

C. camelopardalis (Perry) was for many years confounded with *vitellus*, but the absence of lateral striation, the clearness of marking, and the smoky black interstices between the columellar teeth distinguish it. Common in the Red Sea. Better known by the later name of *melanostoma* (Leathes).

C. pulchella (Swn.).

C. pyriformis (Gray).

Two beautiful and rare shells, allied to each other, and with a connection, too, with *C. Walkeri*, but otherwise isolated. This latter, however, has a characteristic violet tinge, never found in the two under observation, and through this shell there may be a connection with *C. lynx* (L.).

C. pulchella (Swn.) is truly pyriform, whitish, dorsal surface pale brown spotted, with or without a central deep brown blotch, sides spotted, base white, shining, teeth extending over the centre of the base, and labial teeth well developed, red. Length 1¼ inch. Chinese Seas.

C. pyriformis (Gray) and its small variety *C. Smithi* (Sowerby). On dorsal surface pale cinereous, mottled with darker. Truly pyriform in shape, teeth on the outer lip white, on columella red, but not extending far over the base. Eastern Seas. Length 1⅛ inch.

C. moneta (L.).

C. Annulus (L.).

C. obvallata (Lamk.).

Although kept distinct here for the sake of convenience, I think these three are really forms of one species. Typically they are all distinct, and easily discernible, but the varieties are many, especially of *moneta*, of which the best known is *icterina* (Lamk.) a smooth variety. *Barthelemeyi* (Born) is a distorted produced variety from New Caledonia. M. A. T. Rochebrune has added ten so-called species to this section from *moneta* and *annulus*. He gives the distribution as extending from Japan to Corsica (*C. Mercatorum* (*Rochbr.*), and from the Sandwich Isles to Zanzibar. It may probably have been accidentally introduced in the Mediterranean Sea. Most of these new forms are figured in Tryon. Man. of Conch., Cyp., pl. x., xi., and xxiii.

C. Noumeensis (Marie) is a curious form of *annulus* with double orange lines on the back of the shell.

C. obvallata (Lamk.).

(*a*) *calcarata* (var. nov.).

Shell dull, chalky white, uncoloured, otherwise as in the type. Two live shells in good state of preservation exactly similar in Mr. Williams' collection. The geographical distribution of this is not so extended as are the former and better known species. It is recorded, however, from Cook, Society, and Paumotus Isles (A. Garrett), Australia, and New Caledonia. The depressed centre of the dorsal surface is very characteristic.

(XII.) *Upon Variation.*—Far be it from me to augment the mass of literature that of recent years has flooded the world on the most important and, as yet, only partially solved question of *variation* and *limitation* of *species.* The doctrine of specific immutability, is, in these enlightened days, vigorously assailed, but, as just pointed out, there are certain forms of this genus apparently unapproached and with no close relationships *inter se.* The case is widely different with others; and the question arises, 'Is a general *trinomial* system of nomenclature to be preferred for these, the specific, or *binomial* term being rigorously restricted to those prominent types that are the highest result of evolution in their own particular sphere?' Such a proposal has many advocates; and I am prepared to go thus far with them, in signalizing certain leading *colour varieties* and other aberrations from the types, either in form or some other peculiarity, of which, in the course of long investigation, I have seen the frequent recurrence. I agree entirely with the late Dr. Gwyn Jeffreys' remarks (*J. of Conch.* III., p. 234): " Until an International Court has been established to decide the long-mooted question of not only what is a species, but also what are the limits of so-called species, it is useless to do more than argue it. Every naturalist has a perfect right to his own opinion, and time will be the only test of such opinions being correct or erroneous."

But if excessive latitude were given to such a trinomial system, there would be great fear of a too minute critical differentiation, especially in genera that 'sport' more than do the Cowries. Any conchologist, for instance, who has perused Mr. Marrat's researches on the genus *Nassa*,* in which are enumerated no less than 1,321 links by which the whole is bound together, would shrink from the task at being called upon to bestow appellations upon such a vast concourse (there having been hitherto only 250 recognised commonly), and thus the literature of the subject would become wofully embarrassed, and clogged with such a plethora of dog-Latin, as almost to deter the student of the future from voluntarily entering upon so formidable a study.

*On the Varieties of Shells belonging to the genus 'Nassa,' by F. P. Marrat, Liverpool, 1880.

Briefly, then, it is evident that as a plant, insect, or shell may be considered a *perfect representative* of its species only so long as all the distinguishing traits and combinations of character exemplified in the original type are present, so it becomes a *variety*, when, owing to some local or other cause, one or more of these typical characteristics disappear, and change it to that extent.

In the genus under discussion, too much reliance must not be placed on either *form*, *colour*, *texture*, *size*, *pattern*, nor (always) *dentition*; but three or four of these points will be found present in every variety, while, crowning all, there is nearly always an indefinable and intuitive perception that will enable a specialist to recognise and relegate to its proper position with confidence, any individual he may be asked to decide upon.

(*a*) *Form.*—The chief variations are either undue prolongation, as in some specimens from *New Caledonia*, a more effuse growth than is ordinary, or a contracted and stunted form, generally thickened laterally. Monstrosities occur in many of the species.

(*b*) *Colour.*—Colour varieties affect some species far more than others; they run into each other very closely, *e.g.*, *C. tigris* vars.: but certain stand out, constantly recur, and are always recognisable. The *Sandwich Isles* and the *Island of Mauritius* each possess races of Cowries, of various species, in which the whole shell has become semi-pellucid, and of a golden yellow or straw coloured hue, almost free from markings. These probably come from deep water, and, in a few species, unicolorous green varieties also occur.

(*c*) *Texture.*—Varieties from deep water are sometimes thinner than usual, and in certain forms, *e.g.*, *C. carneola*, the lateral thickening spoken of under (*a*) gives a greater ponderosity to the shell.

(*d*) *Size.*—Certain species, as *C. lynx*, *carneola*, etc., often attain unusual size, three or more inches in length, when normally only a third or quarter of that extent. Again, *C. caurica* has a very small variety, not much more than ½ inch, and many other kinds vary in a similar manner.

(*e*) *Pattern.*—This has already been spoken of. The design of the adult Cowry is, as a rule, wonderfully uniform. Occasionally as in *C. tigris, var. ionthodes* and a form of *C. lynx*, large triangular blotches cover the dorsal surface, and, as in *stolida var., gelasima* certain spots, present in the type, disappear. Again, the pattern is often blurred over by the last deposit of colouring matter, as in *C. Arabica var. niger*, the black variety of *mappa*, *C. helvola var. Mascarena*, and others.

(*f*) *Dentition* is the least variable point, and the greatest holdfast in detecting a species, in nine cases out of ten. But in *C. stolida*, *C. staphylœa*, etc., much inconstancy is shown, so even this cannot always be relied upon.

No hybrids appear to have been ever detected, unless, indeed, some of the nearly akin forms we are noticing in this paper prove such; but these are questions for the future scientist to decide. It is to be hoped now, with the establishment of Marine Biological Laboratories, we shall be able in the course of a few years to learn something more definite of the life-history of these creatures, whose external skeletons are but an insufficient sign-post for guidance, and, till this achievement, we must be content with only very imperfect knowledge of the affinities and relationships of so interesting a group as Cypræa.

(XIII.) *Notes on certain species and proposed varieties.*

Cypræa *mappa* (L.), (Type, *cf.* Reeve, Conch. Icon., pl. vi., f. 18; Perry, Conch. pl. xxiii., f. 1, as *alga*). Three well known varieties of this well known Eastern shell occur.

(*a*) *panerythra* (var. nov.); *cf.* Sowb., Thes. Conch., pl. v., f. 28. Shell uniformly suffused with pale red or deep rose, which is generally deepest at the base. Teeth plain, or only slightly tinged with yellow. N. Caledonia, etc.

(*b*) *subsignata* (var. nov.); *cf.* Sowb., *ut suprà*, f. 24, 25, 27. Base spotted with bright lilac, and conspicuously blotched with darker purple towards the centre; teeth conspicuously orange. S. Brandon Shoals, Indian Ocean, etc.

(*c*) *nigricans* (Mont.); suffused with black, extremities rostrate. Var. *monstr.* N. Caledonia.

C. pantherina (Sol). (Type, Reeve, Conch. Icon., pl. iii., f. 7; Sowb. T. C., pl. xi., f. 69, 70). Five colour varieties.

(*a*) *badionitens* (var. nov.). Shell smaller than the type, somewhat transparent, dorsal surface partly suffused with light golden brown, spots well nigh obsolete. A rare and striking variety.

(*b*) *theriaca* (var. nov.). Shell entirely, with the exception of the extremities and base, suffused with rich golden red-brown, not disposed in blotches as (*a*). Figured in Sowerby, Thes. Conch.. pl. xi., f. 71. Common. Some specimens are almost, if not quite, *black*, and a monstrous form also occurs pretty frequently with warty extraneous growth, principally at one or other extremity (*theriaca distorta*).

(*c*) *albonitens* (var. nov.). Spots smaller, and more distant, giving therefore greater prominence to white body colour of the shell.

(*d*) *juvenca* (var. nov.). Very pale fawn colour, spots almost obsolete, owing to the enamel being laid on more thickly than is ordinary. This variety, which usually has some tendency to distortion, often resembles *C. umbilicata* (Sowb.), the base, however, will at once show its specific affinity.

(*e*) *syringa* (var. nov.). Shell with pale lilac tinge. Spots dark purple. Uncommon.

Note.—Weinkauff, in Küster's "Conchylien-Cabinet," has figured this and many of the above colour varieties.

C. tigris (L.). (Type, Reeve, C. I., pl. iv., f. 12, *a* and *b*; Sowb., T. C., pl. xxi., f. 172—3—4). The painting of this well known species is most variable; the principal colour varieties that stand out are as follows:—

(*a*) *flavonitens* (var. nov.). (Sowb., Thes. C., pl. xxi., f. 175.) Suffused with rich yellow or orange. Spots often more sparsely distributed. A very beautiful and well known form from Mauritius chiefly, also from the Fiji Islands.

(*b*) *hinnulea* (var. nov.). Pale grey brown coloured, spots almost obsolete. Of very infrequent occurrence, compared with the last variety, corresponding to *C. pantherina* var. *juvenca*.

(*c*) *russonitens* (var. nov.). Dorsal surface suffused with blackish grey, partly obscuring the spots; dorsal line an irregular broad blood coloured stain running longitudinally. A rare and striking variety. I have two, formerly in Mr. Lombe Taylor's collection.

(*d*) *chionia* (var. nov.). Spots fewer in number; dorsal surface therefore whiter in appearance. This runs into (*a*) frequently, and corresponds to *C. pantherina* var. (*c*).

(*e*) *ionthodes* (var. nov.) Dorsal surface with large, often triangular, black blotches, thus partly obscuring the ordinary markings. This colour variety is not very frequent.

(*f*) *lyncichroa* (var. nov.). Spotted and coloured with blue and fawn in pattern resembling *C. lynx* (L.), dorsal sinus reddish, very distinct; shell usually rather stunted, and smaller than the other forms, sides and base white.

(*g*) *zymecrasta* (var. nov.). Dorsal spots obsolete, the surface entirely suffused with mixed blue red and brown wash, probably owing to the enormous extension of the sinus, from some defect in the mantle of the animal. I have seen a few specimens of this colour variety, and the effect is most striking. Sides as in the type, spotted, base white, normal.

C. decipiens (Smith). (*Proc. Zool. Soc.*, p. 482, pl. xlviii., f. 8, 1880). This, one of the most interesting discoveries in the genus of late years, has been amply confirmed by the arrival of several specimens, now in the National Collection, and received from Exmouth Gulf, W. Australia, through Mr. T. H. Haynes, and I also have one, from the same source, only acquired whilst these pages were passing through the press. While it seems to present a very faint affinity with *C. mus* (Linnæus) in the base, and columellar lip, it is very near *C. Thersites* (Gaskoin) in all other respects. I have carefully examined the unique *C. marginata* (Gaskoin), also in the National Collection, and conclude it is the young form of *Thersites* or *stercoraria*, though, for convenience sake, I have still kept it distinct in the accompanying list.

C. caput serpentis (L.). The following is the description, from Reeve., Conch. Icon., sp. 44. Cypr. testâ subquadrato-ovatâ, depressâ, planâ, crassâ, solidâ, dorso, acuminato, dentibus conspicuis, subelongatis ; nigricante fuscâ, dorso guttis niveis circularibus inæqualibus asperso, extremitatibus albicantibus, dentibus, et aperturæ fauce fumeo-albidis. Long. 1⅜ inch, Lat. 1 inch. Hab. Pacific Ocean, India, &c.

C. caput anguis (Phil.), 1849, in *Zeitschrift für Malako-Zoologie*, p. 24. "C. testâ oblongo- ovatâ, valdé convexâ, lateribus incrassatis angulatis ; basi convexâ, nigro-fuscâ, in dorso alboguttata, extremitatibus albidis ; interstitiis dentium lacteorum aperturæ fuscis. Long. 11½‴, Lat. 7½‴."

"Coloribus omninó cum C. capite serpentis convenit, sed maculæ albæ ad extremitates vix conspicuæ, dentes aperturæ in utroque labio, sedecim, lactei, sulcis fuscis divisi, producti, incisurâ ad basin aperturæ lata, in sinistrum flexa, quibus notis forma oblonga, lateribus longé minus dilatata accedit."

This species is said by Mr. Garrett, Mr. Brazier, and Mr. G. F. Angas (all of whom have collected it plentifully, the first at the Sandwich Isles, the others in Australia) to be quite distinct, and to differ mainly from *C. caput serpentis* in the smaller size, less dilation of the sides, and more obscure marking. I apprehend all these specimens will be but varieties of the commoner form, distinguished by their greater convexity, and if this surmise be correct, the true *C. caput anguis* of Philippi is a lost species. Anyhow the shell is not known in this country, and I would appeal to any conchologists who may collect it, or what they suppose to be it, in any quantity, to send a supply home either to the National Museum or to private collections, that we may have an opportunity of judging in England as to its specific merits. Neither Mr. Sowerby, Mr. E. A. Smith, or myself have ever seen a specimen.

* * * * *

A truly distinct and extraordinary form has, however, lately come to hand from Hong Kong, where it was collected by Dr. Hungerford. Through the kindness of Mr. Sowerby I have become possessed of this shell, and have much pleasure in appending a photographic representation of both it and typical *caput serpentis* for comparison (Fig. 1, 1[a], 2, 2[a]). The specimen of the latter selected is much the most clearly marked I have ever seen. The following is a description :—

C. caput draconis (sp. nov.). C. testâ ovatâ, convexâ, solidâ, dorso elevato-rotundo, aperturâ latiore quam in C. capite serpentis, dentibus utrinque quinquedecim, dorso brunneo confusé et obscuré reticulato, lateribus strictis, nequâquam depressis, extremitatibus cinereo-nigris, dentibus cinereo brunnescentibus, basi et aperturæ fauce brunneo-nigris. Long. 1⅝ inch ; lat. $\frac{7}{16}$ inch. Hab., Hong Kong.

This shell differs from the type *C. caput serpentis* in many ways.

(i) In the straightness of the sides.
(ii) Greater convexity.
(iii) Difference of marking, and descent of the pattern almost to the base.
(iv) Wider and greater sinuosity of aperture.
(v) Dark ash coloured extremities.
(vi) Flattened dark coloured base, as in *C. Mauritiana*.

From *C. caput anguis* it would appear, comparing it with Philippi's description, to be distinct in the following particulars :—

(i) Sides not thickened, "incrassatis."
(ii) Base not convex.

(iii) Difference of marking and colour painting.
(iv) Dark ash coloured extremities.
(v) Ovate, not oblong.

It would seem to agree with caput anguis alone in its greater convexity and sinuosity of the aperture. The base is exactly like that of *C. Mauritiana* in miniature, and adds another link to that species with *C. caput serpentis.*

C. Arabica (L.). I can find no distinguishing points, that are permanent, to separate *C. histrio* (Gmel.) and *reticulata*[a] (Martyn) specifically from the type. *C. amethystea* (Linnæus) is a name apparently given to the young or decorticated shell. *C. eglantina* (Duclos) is a shining brown, grey, or green thickened enamelled form, and *C. niger* (Roberts), the handsome elongated shell from New Caledonia. *C. intermedia* (Gray), a shining, somewhat obese, laterally thickened variety, considered distinct by Mr. A. Garrett, who collected it in the Paumotus and Society Islands (*cf. J. of Conch.*, 1879, p. 114).

C. Walkeri (Gray).

(*a*) *Bregeriana* (Crosse). (Sowb., T. C., pl. xxxvii., f. 536). This shell differs from the type in the orange base, with no violet tinge, teeth twenty-two or twenty-three in number, on each lip, dorsal surface banded much as in *C. Walkeri*, enamel pitted with small white specks, as in *C. testudinaria* (L.). This is very characteristic, and some authors, as Weinkauff, raise it to a specific position.

Mr. Edgar Smith, F.Z.S., has, within the last few weeks, received at South Kensington three specimens of a shell which I believe will be shortly described by him, collected by Mr. Ruddle, off the coasts of N. W. Australia. The shells are all alike, except in size, the larger of the three being of the shape and magnitude of *Bregeriana*, the two others smaller. Colour brick red, with a touch of grey, shining,

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[a] The dorsal pattern of *C. Arabica* is dark brown parallel longitudinal lines everywhere broken up and confused; *histrio*, more an open net-work, with round white spaces between; *reticulata* exactly intermediate between these two.

faint trace of transverse band on the larger specimen, underside with dentition as in *Bregeriana*, teeth about twenty-one on each lip, a basal central patch of deep red-grey. The small white pitting is in these three shells extremely characteristic, and although they may be a distinct species, yet there is no doubt they impinge very closely on *C. Bregeriana*.[a]

C. fimbriata (Gmel.). Reeve, f. 18, f. 92. Sow., T. C., pl. xxxii., f. 387–391. This species, always extremely variable, is known mainly by the violet painting of its extremities.

(*a*) *C. microdon* (Gray) I consider but a variety, with very beautifully minute teeth, extremities violet.[b]

(*b*) *unifasciata* (Mighels). This variety is thus characterised by Mr. A. Garrett (*J, of Conch.*, 1879, p. 120:— "Larger (than *C. fimbriata*), teeth coarser, less numerous, and the ground colour, which is of a more bluish tint, marked with a more or less broken, transverse, yellowish-brown band. Both species have the terminal pink spots as well as the profusion of small yellow dots."

(*c*) *macula* (Adams), sp. Sow., T. C., 379—381, more pyriform than the type, with the extremities dark purple brown.

(*d*) *Cholmondeleyi* (var. nov.), Sow., T. C., pl. xxxii., f. 387, 388. This magnificent form is very uncommon, there is a good specimen, formerly in the collection of Reginald Cholmondeley, Esq., now in the Museum of the Owens College, Manchester. Length 1⅛ inch, breadth ⅝ inch. Native of Australia. The main distinction of this variety is its size, and greater dorsal effusion. Mr. J. M. Williams possesses Mr. Hugh Owen's original specimens; almost as large as the type now figured, pl. ii., f. 15.

C. fabula (Kiener) } *cf.* Sowb. Thes. Conch., pl. xxxii.,
C. felina (Gmelin) } f. 393-395.

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[a] The other variety of *C. Walkeri*, (*b*), *amabilis* (Jousseaume), is said by the author to differ in the more produced extremities, which are a little recurved, narrow bands dorsally, and only the inner lip purple tinted. I have never seen this. It is figured in Tryon. Man. Conch. Cypræa, pl. xiv, f. 1, 2.

[b] The Rev. R. B. Watson (Rep. on Gast. Challenger Expedition, Vol. XV., p. 424) considers this a good species, so do Messrs. Roberts, Reeve, and Sowerby.

These species are usually considered forms of one, but I fancy there is more difference between them than is usually given credit for.

C. fabula is ovate, stunted, not spotted at the extremities, dorsal surface suffused with brown, laterally thickened, base white, mouth narrow, teeth coarser than in the next.

C. felina and its variety *ursellus* (Gmel.) (the latter characterised by white base as opposed to yellow in the typical form) are cylindrical, not thickened laterally, spotted very clearly, with large blotches at the sides, dorsal surface cinereous, brown extremities spotted, mouth wide, teeth about fourteen in either lip.

C. caurica (L). The type of this abundant mollusc is well given by Sowerby, Thes. Conch., pl. xxiii., f. 188, 189, and Reeve, Conch. Icon., pl. xi., f. 46. Reeve says truly, "This specimen varies from long and rounded forms with thin sides, to short and depressed with thickened sides." Long. max. 1⅞ inch. A small full grown form from my collection may be seen in the plate appended (fig. 9), only ¾ inch in length. East Indies, general.

(*a*) *oblongata* (var. nov.), (fig. 8). Shell oblong, thinner than the type, and often of much greater length, say 2¼ inches, somewhat effuse, back pale green, densely clouded over with brown confused markings. Sides rounded, thin, scarcely spotted, in one of my specimens dark banded, teeth about eighteen, not so prominently developed as in the type, base usually yellowish white, the base of typical *caurica* being usually flesh colour, and mouth wider. Same localities as above. There is every gradation between this and the typical form. This may be *C. elongata* (Perry), *cf.* Conch., pl. xxii., f. 5, but the delineation is, as usual, fantastic in the extreme.

(*b*) *concava* (Owen). An almost distorted state from R. Gambia; *cf.* Sow., Thes. Conch., pl. xxix., f. 318, 319.

(*c*) *obscura* (Rossiter). A black banded var from New Caledonia.

C. cruenta (Gmel.) is very nearly allied to the preceding, and the variety *coloba* (fig. 7), so called from the stunted appearance, is also figured in Sowb. Thes., f. 190, as *caurica var.*; it would appear nearer this species: the base is always brighter coloured, and teeth interstices bright red. I possess stunted *caurica*, with which this var. cannot be mistaken.

There are two species, *C. tabescens* (Sol.) and *C. teres* (Gmel.), allied to *C. caurica* (L.).

The former of these is at a glance known by its teeth, small and numerous, and white base; but on the dorsal surface it is often impossible to recognise it as distinct from *caurica*. And I have another variety which is tending to the form of *teres*. The two are always, however, distinguishable, and I do not doubt the genuineness of the specific rank they hold, *C. teres* itself being a narrow, cylindrical, delicately marked shell, with fine, almost obsolete teeth. It ranks among the more prized of the smaller kinds. *Cf.* Sowb., pl. xxvii., f. 259, 260.

C. tabescens (Solander). Type, *cf.* Sowb., T. C., pl. xxvii., f. 261, 265.

(*a*) *latior* (var. nov.). *Cf.* Reeve, Conch. Icon., pl. xiv., f. 66_a. A pyriform shell, broader and more stunted than the type, with brighter coloration, and very distinct dorso-lateral spots. A handsome and rare form, almost sub-specific.

(*b*) *pellucens* (var. nov.). Transparent form, from the Sandwich Isles, dorsal markings indistinct, pale brown. Some specimens large and effuse, others pyriform and broader as var. (*a*).

(*c*) *alveolus* (Tapparone Canefri). I do not know this form. It is reported from Mauritius, from whence also I have seen unicolorous, thickened, dark green enamelled specimens, shape as in the type, which may be signalized as (*d*) *elaiodes*.

C. Rashleighana (Melvill). *J. of Conch.*, V., p. 288, 1887, pl. ii., f. 26; also fig. 3 in photographic plate appended.

As it is only four months since this was described, it may not be amiss to transcribe the particulars. "C. testâ ovatâ, anticé subprolongatâ, dorso convexiusculo, lilacino, tribus brunneis fasciis decorato, fasciâ centrali distinctiore et latiore, lateribus albis parcipunctatis, extremitalibus immaculatis, dentibus parvulis, albis, basi albâ nitente. Long. 18 mm., lat. 11 mm. Habitat ?"

"A very pretty addition to the known species of cowry, albeit of small size, the disposition of the brown bands on the lilac ground is a little like the arrangement in *C. sanguinolenta* (Gmelin), the shape and upper surface slightly recall *C. macula* (Adams), though the underside has a perfectly different disposition of teeth, *C. macula* being allied more to the *fimbriata* section of the genus. Nothing at all nearly resembling this cowry is to be found in the National Collection, or in the latest monograph (that of Mr. Raymond Roberts). With this shell I have associated the name of my late friend Mr. Jonathan Rashleigh, Junr., of Menabilly, Cornwall, who died December, 1872, aged only 27. His collection of Cypræa was extremely large and perfect, and had he lived he would have made great mark in a science to which he was profoundly attached.

Of this unique shell I am glad to be able to give a photographic representation (fig. 3). I consider it now nearer to *C. tabescens* than *macula*, or any of the *fimbriata* section, but differing as much from the stunted form of *tabescens* on the one hand, as *C. teres* does from the smaller, more elongate variety.

C. stolida (L.). Type, Reeve, Conch. Icon., pl. xiv., f. 67^a, 67^b. Sowb., T. C., pl. xxx., f. 327, 329.

(*a*) *moniontha* (var. nov.), (fig. 4). Dorsal surface rounded, not humped, with one rounded blotch only, and occasionally this is absent, sides streaked and speckled, teeth not so prolonged, white. Length in largest specimen 1¼ inch. This is intermediate between the type and *C. brevidentata* (Sowb.). A common form, almost a sub-species.

(*b*) *diauges* (var. nov.), (fig. 5). Yellow, shining, semi-pellucid, shape as in type. One pale central dorsal blotch, otherwise unspotted and uniform pale yellow, including the extremities and teeth. Bears the same relation to the type that *C. Helvola*, pale var., bears to that shell. Mauritius.

(*c*) *gelasima* (var. nov.). Shape as in type, with flattened dorsal surface, pale olive green, very delicately pale brown spotted, and with no dorsal blotch, extremities pale fawn. Teeth as in (*b*). Mauritius. A beautiful variety in the National Collection.

(*d*) *Crossei* (Marie). A large, attenuated, almost monstrous form, from New Caledonia.

N.B.—*C. brevidentata* (Sowb.) and *C. erythræensis* (Gray) both seem extreme forms of this species. I would refer to Reeve, Conch. Icon., pl. xiv., f. 63, for a differentiation of the latter. The characters are clear enough when compared with the type, and not with intermediates. It is, however, always of uniformly smaller size. Found at the Red Sea, as far S. as Zanzibar. My largest specimen only measures ¾ inch in length. *C. brevidentata* (Sowb.) is well figured in Thes. Conch., pl. xxx., f. 325, 326. A very rare form, from Borneo, of which but few examples are known in European or American Cabinets.

C. clandestina (L.). The type of this common species is pale whitish, oblong, ornamented with very fine zigzag brownish yellow lines, sides and base white: teeth very well marked. It varies extremely in size, the largest specimens I have seen are in the collection of Mr. J. M. Williams, of Liverpool, nearly 1 inch in length.

(*a*) *candida* (Pease). A pure white unmarked variety.

(*b*) *Artuffelli* (Jousseaume). Is this the same as *C. asellus* var. figured in Sowerby, Thes. Conch., pl. xxx., f. 327*? It compares well with the plate in Tryon. Man. Conch., pl. xvi., f. 61. I recollect this specimen in the collection of my late friend Mr. Rashleigh, but have had no opportunity of comparing it, as since his death in 1872, his collections have been left packed in the Bedford Pantechnicon, London, and are not in a condition, therefore, to be consulted.

(*c*) Mr. Williams also possesses a very ovate form of this species, marked dorsally with leaden blue. Should subsequent investigations cause this to be entered as a good variety, I would suggest the name var. *C. passerina* (*cf.* Sowb., Thes. Conch., f. 534).

(*d*) *aberrans* (Ancey). I do not know this form.

C. capensis (Gray); *cf.* Reeve. Conch. Icon., pl. xvii., f. 86. Sowb., T.C., pl. xxix., f. 306, 307, 308 [a] This shell, with C. Adamsonii (Gray), were originally made sole types of the genus *Cypræovula*, the surface being ribbed transversely. *Luponia* (Gray) was characterised by the pyriform shape, smooth, polished, spire concealed and depressed, inner lip plaited-toothed, outer inflexed and crenate. Type, *L. Algoensis* (Gray); *cf.* Sowb., Thes., pl. xxix., f. 311, 312.

As announced previously in this paper, I recently obtained a specimen of a very extraordinary shell from Port Elizabeth, S. Africa, which appears to unite these two forms, types of two different genera of Gray, in its own person. The following is the description:—

C. amphithales (sp. nov.), (fig. 19).[b] C. testâ rotundato-pyriformi, subumbilicatâ, stramineo-albâ, lateribus brunneis maculis conspersis, latere dextro extremitatibusque ambabus angusté marginatis, aperturâ angustiore quám in *C. algoensi* latiore quám in *C. Capensi*, dorso omninó lævi, brunneâ centrali maculâ decorato, basi transversim liristriatâ, labio dentibus octodecim, quasi liri-duplicatis, columellaribus ut in *C. capensi*. Long. 1 in. Hab., Port Elizabeth.

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[a] The annexed plate (fig. 20) shows perhaps the finest specimen known of *C. capensis* (Gray), which is in my collection. The dorsal blotch is of a fine rich brown, and the transverse liræ unusually clear and sharply cut.

[b] The specific name, ἀμφιθάλης, *blooming out on both sides*, was suggested by the ramifications presented on the one hand towards Cypræovula, and on the other towards Luponia.

The upper shoulder of this new form resembles *C. algoensis* (fig. 21), with which it is of uniform size. In shape it assimilates either shell; it is not, however, deeply umbilicated, as is *C. capensis*, the base is white, with numerous striæ, the converging liræ developing into fine labial teeth, two liræ meeting at the tooth projection, eighteen in number, while I have counted as many as twenty-five on well developed *C. capensis*. The columellar teeth, as in that species, are represented by the fine projecting liræ alone, thus differing from all the *Luponiæ*, which have developed teeth on both sides, with the exception of *L. edentula*. But the smooth dorsal surface, size of the aperture, and the spotted lateral margins, are as in *Luponia*.

C. gangrenosa (Sol.). Reeve, Conch. Icon., pl. xviii., f. 96*a*. In the typical form, the tips, fuscous above, orange beneath, are characteristic.

(*a*) *Boivinii* (Kiener), fig. 96 *b*. Rientzii (Dunk.). This is a large shell, dorsal surface grey, the sinus usually marked by brown streak. Extremities uncoloured. Very close to *erosa* (L.), var. *a*. *cf.* Sowb., Thes. Conch., f. 232. From Zanzibar.

(*b*) *melanosema* (var. nov.). Smaller, the extremities of dorsal surface with very wide, black, suffused extension of marking, sides white enamelled as far as dorsal sinus. I have seen fine specimens of this in the National Collection, and in that of Mr. Williams. From Mauritius. This may be what Dunker intends by his var. *Rientzii*, but authors seem much mixed in their opinions, and the name and description are hopelessly confused with *Boivinii*.

C. erosa (L.). Type Reeve, Conch. Icon., pl. xi., f. 43. Sowerby, Thes. Conch., pl. xviii., f. 111—112. There are several constant varieties of this common and well-known species, the type of which may be described as follows:—Shell ovate, oblong, somewhat flattened, but few specimens exceeding long. 1·60, lat. 1·12 mm. The back buffcoloured, with many small round white dots, more copiously besprinkled over some parts than others, the sides in the type callous, somewhat extended, pitted, and crenated, teeth (in largest specimen) about nineteen, very strong and well developed, underside white, but rarely spotted, livid-blotched at the sides, this being almost central, and broadly square. Habitat, India, Ceylon, coast of the Pacific Islands, including Mauritius, coasts of tropical Australia, in fact universally distributed over the East.

(*a*) *phagedaina* (var. nov.), (fig. 11). Sowb., T. C., pl. xviii., f. 113. Without the livid lateral blotches; unspotted shining white underneath, teeth about eighteen, not so prominently developed as in the type, and much resembling var. *Boivinii* of *C. gangrenosa*. Back pale, light greenish brown, spots often very confused and indistinct.

(*b*) *chlorizans* (var. nov.), (fig. 12). Dwarf. ·80 long., ·60 lat. Form as in type. Lateral blotches conspicuous both on upper and lower sides. Back very dark olive green, spots clear, numerous and distinct.

(*c*) *straminea* (var. nov.), (fig. 10). Shell semi-pellucid, back delicate transparent pale ochreous yellow, spots barely visible, livid lateral blotches present, teeth about sixteen, very well developed, underside pure white, shining. Hab., Mauritius, deep water. Size as in type.

(*d*) *nebrites* (var. nov.), (fig. 13). Sowb., Thes. Conch., pl. xviii., f. 114, 115; Tryon. Cyp. f. 90. General shape slightly more compact and stunted than in the type, varying (in my seven specimens) from 1 to 1·30 inch in length, colour warm flesh, back yellow-brown, the lateral blotches, which are most conspicuous, black-brown, and extending towards the centre, not visible below. Extremities markedly lineated with red lines. Teeth well developed, uncoloured, but not to such an extent as in the type. Base pale red-brown with linear brown lines and dots, almost exactly similar to *C. ocellata*, with which species and typical *erosa* is here presented a link; indeed in the largest of my specimens of this variety some of the dorsal spots are distinctly ocellated. I have never, however, seen in *C. ocellata*, or any of the "*spurca*" group, the slightest symptom of the square lateral blotches, so characteristic of *erosa*, though absent in one of its varieties. Locality, Borneo.

C. ocellata (L.) differs mainly from all these varieties by its greater distinctness of ocellation and marking. It is a neater and more compact shell in every way.

(*a*) *palatha* (var. nov.), (fig. 14). Ocellations less prominently coloured, with a tendency to become obsolete, otherwise as in the type. This variety connects *ocellata* with *erosa* still more closely, the two distinctions which still remain being absence of blotches on the sides, more distinct lateral clouding, and the conspicuous orange-brown tinting of the teeth and extremities on the underside. The specimen in the plate is in Coll. Mus., Owens College, Manchester, formerly in that of Mr. Reginald Cholmondeley, of Condover Hall, near Shrewsbury.

C. spurca (Linn.). *Cf.* Sowb., T. C., f. 118—122. This common Mediterranean and Atlantic Island species is not so variable as *C. erosa*; some of its forms are more pyriform, and the marking is more distinct, often with slight ocellation on the dorsal surface; I hold that *C. flaveola* (L.) is of true specific rank, although I am not quite so sure that *C. cernica* (Sowb.) from Mauritius is not a more beautiful and tropical form of *spurca*, var. (*a*), and as such I have placed it in the subjoined table. I certainly have intermediates. Sowerby (Thes. Conch., pl. xxvi., f. 238—240) remarks upon the dorsal white spots being round and clear. I have a specimen with distinct trace of ocelli, as in *spurca*. *C. flaveola* seems to be constant in small size, oblong form, and clear dorsal marking. It connects the *erosa-spurca* section with the *cribrariæ*.

C. spurca (L.). (*b*) *Verdensium* (var. nov.). Smaller than type, compact, sides slightly thickened, dorsal surface spotted in a rather confused manner, brown, extremities lineated, teeth finer than in *spurca*, base white, somewhat spotted. Habitat, St. Vincent, Cape de Verde Islands. It much resembles a small form of *C. turdus* (Lam.), *ovata* (Perry).

Allied to *C. Thomasi* (Crosse), *Jour. de Conch.*, 1865, pl. vi., f. 3, of which I have only seen description and figure, the habitat being unknown. I hesitate before pronouncing them identical; the columellar teeth are described as being semi-obliterated, size ·7 inch.

If it were not for the constancy of the lilac base in *C. Listeri* (Gray) and the chestnut-brown hue of *C. Helvola*, how like they are to some forms of species we have just been commenting upon! But *Listeri* is not a variable shell, and the peculiarity just mentioned always seems to distinguish it. Through it we come to *C. albuginosa* (Mawe) and *poraria* (L.), also with annulated ocelli on the back, and purplish base.

C. Helvola (L.) is one of the most easily distinguishable, and yet most variable of the genus. The only species with which it could possibly be confounded is *C. citrina* (Gray), which has more teeth, and yet not so prominently developed, dorsal surface olive brown, with rounded spots of paler colour, a rare form, found in Ceylon, Mauritius, and off N.W. coast of Australia (*fide* J. F. Bailey sec. Roberts). Sowb., Thes. Conch., pl. xxv., f. 218, 219. The type of *Helvola* is figured in Reeve, pl. xv., f. 72; Sowerby, pl. xxv., f. 214—216. A most abundant Eastern species. Found in every group of Polynesian islands worked by Mr. A. Garrett; also in India, Ceylon, Mauritius, &c.

(*a*) *Mascarena* (var. nov.). Smaller, and of richer uniform burnt sienna brown colour, almost or entirely obliterating the white, grey, and brown spotted dorsal ornamentation. Native of the Mauritius. This is a colour variety, and I have traced every gradation to the type. *C. chalcedonia* (Perry), pl. xix., f. 6, is apparently intermediate between this and the type.

(*b*) *argella* (var. nov.). Shell usually oblong-ovate, sides not thickened, colour orange-brown, entirely enveloping the surface, the star like white dots appearing clearly defined over the back, the effect being exactly antagonistic to the normal condition, where brown specks appear on the dorsal surface on a greenish or bluish-white ground. I have four specimens of this variety, and have seen many others. Habitat, with the typical form.

(*c*) *Hawaiiensis* (var. nov.), (fig. 18). Pellucid, shining, straw-coloured on both sides. There are two forms of this well-known variety, one incrassated laterally, bearing a strong superficial resemblance to *C. cernica* (Sowb.), the other with straight sides. Often the extremities, of so conspicuous a lilac in this type, present a pale reflection of that colour; otherwise they are uniformly straw-coloured. From the Sandwich Islands. Also *cf.* Sowb., T. C., pl. xxv., f. 217.

C. poraria (L.). Type Sowb., Thes. Conchyl., pl. xxvi., f. 236—237. An abundant Eastern shell. The lilac-backed unspotted young shells are very bright and beautiful. A curious monstrosity is mentioned by Brazier (*Proc. Linn. Soc. N.S.W.*, VI., p. 202), destitute of white dots, and with the aperture shaped liked the figure 8.

(*a*) *Kauaiensis* (var. nov.). Pellucid. Pale yellow with purple tinge. From Kauai I., Sandwich Isles. Another of the characteristic Sandwich Island varieties.

C. Lamarckii (Gray). Reeve., C. Icon., pl. x., f. 37., Sowb., Thes. Conch., pl. xvii., f. 106, 107. Shell ovate, somewhat ventricose, slightly prolongated at either extremity, pitted at the sides, teeth about sixteen on either side, back ochreous, profusely dotted with large and small round white spots, some of them ocellated, but occasionally with no signs of ocellation, extremities lineated as in C. turdus and C. erosa. Sides scarcely thickened, brown-spotted. Length 1⅜ in., lat. ⅞ inch. Locality, Mozambique, &c.

(*a*) *redimita* (var. nov.), (fig. 16). Shell somewhat stout, slightly flattened at the base, extremities less produced than in the type, but more so than in *C. turdus*, aperture fairly wide, two last anterior labial teeth distinct and projecting, as in *Lamarckii* and *miliaris*. Dorsal surface pale-ochreous, indistinctly marked with obscure whitish spots, laterally thickened with white callosity on each side, and a double row of brown spots (almost becoming blotches in one specimen), which impart a special character at first sight. Size about the same as the type.

I take this shell to be very well developed and full grown *Lamarckii*. I had at one time, some eighteen years ago, when I gave the MSS. name of *redimita* to the specimens then acquired at a dealer's in Liverpool, imagined the species was a new one. I have found an example among the Cholmondeley shells now at Owens College, rather larger than my own, but not so well marked as that now photographed.

The underside is the same as *C. turdus*, and were it not for the projecting ridges of the two last labial teeth, which are never found in that shell, I should have been inclined to connect the two species more closely.

C. miliaris (Gmel.); (*a*) *magistra* (var. nov.), (fig. 6). A very large variety, lately acquired through Mr. G. B. Sowerby, from Japan. Character the same as in the type, but teeth very well developed and size, long. 2⅛, lat. 1⅛ inch. I have seen five or six other specimens in no other way differing. It is a handsome shell, and in fine condition; it slightly resembles *C. guttata* on dorsal surface only. I consider *C. eburnea* (Barnes), often reckoned a mere albino form of this, a sufficiently good species.

C. miliaris (Gmel.), *C. Lamarckii* (Gray), and *C. Listeri* (Gray) are commented upon by the Rev. R. Boog Watson, B.A., F.L.S., in his "Report on the Gasteropoda, Voyage of H.M.S. Challenger," Vol. XV., pp. 424, 425. To quote his remarks: "In classing the Challenger specimen (of *C. miliaris*, collected in eight fathoms, off Wednesday Island, Cape York) as *Gmelin's* species, I mean simply that it agrees with shells bearing Gmelin's name in the British Museum. My own opinion is, that these are the same as others marked *C. Lamarckii* (Gray), and that both are distinct from *C. erosa* (L.), of which Dillwyn (Vol. I., p. 461, No. 50) regards Gmelin's species as the young, while Deshayes simply unites them, followed herein by Gray (*Zool. Jour.* Vol. I., p. 504), who, however, at the same time resuscitates the *Cypræa miliaris* (Gm.) in the form of two new species, *C. Lamarckii* and *C. Listeri*, of his own making, but one of which at least, if they be good species, ought to have borne Gmelin's name." He then quotes Kiener, Reeve, Sowerby, and Weinkauff as further complicating the question.

I think the following distinctions amply serve to differentiate successfully any examples of the species that puzzled Mr. Watson :—

C. miliaris (Gmel.). *Never* possesses lateral spots; dorsal surface covered with small white round spots, which are *never* eyed, or, at all events, extremely rarely.

C. Lamarckii (Gray) *always* has lateral spots, dorsal surface with spots larger, round, and *often* ocellated.

C. Hungerfordii (Sowb.), 1888. This very handsome addition to the genus, procured by Dr. Hungerford at Hong Kong, is conspicuous for its pyriform shape and coronal of spots wreathing the dorsal surface. Sides white enamelled, thickened. Teeth fine, about twenty-four labial. Base as in *C. carnicolor* (Duclos). Long. 1 ½ inch; lat. ⅞ inch. I think should be placed between *onyx*, *spadicea*, and *physis*; to var. *achatidea* of this latter it approaches, but not very nearly.

C. subviridis (Reeve). Conch. Icon., pl. xii., f. 48; Sowb., Thes. Conch., pl. xxii., 176—178. Differentiated successfully by Mr. Reeve in 1835, having till then been confounded with *erroneS.* A local species; the dorsal blotch is occasionally absent. A large variety occurs in New Caledonia (*cf.* Sowb., f. 176), and a beautifully coloured form (*cf.* id., f. 358), is figured as being in the Lombe Taylor Collection.

C. errones. (L.). Sowb., Thes. Conch., pl. xx., 156, 157, 158. This species mainly varies as to the presence or absence of the brown dorsal blotch, and the plain or saffron colour of the teeth; the specimens vary much, also in size, the smaller being the most brightly coloured.

(*a*) *chrysophæa* (var. nov.). Surface entirely coloured golden brown, enamel of base and sides shining, pale yellow, teeth and form as in type. A most beautiful colour variety in my collection from Port Blair. Andaman Islands.

(*b*) *C. Coxi* (Brazier) and (*c*) *C. Sophiæ* (Brazier) are varieties; the latter only differs in more lateral development of white enamel, and yellow teeth, and of this I possess a fine example; the former a pale brown uniform variety, from N. W. Australia; dentition and base as in the type. In the Cholmondeley Collection, Owens College, Manchester.

C. cribraria (L.). *Cf.* Reeve, C. I., pl. xvi., f. 81. Sowb., Thes. Conch., pl. xx., f. 161—164.

(*a*) *translucida* (var. nov.). Of this well-known and handsome species I have pellucid varieties from the Sandwich Islands, which have been named *Peasei*, but this is a misnomer. It will be better to rechristen them *translucida*, as *Peasei* (Sowb.)[a] is preoccupied by a different species. Form and dentition as in type.

(*b*) *Exmouthensis* (var. nov.). Another fine form I noticed recently in the Natural History Museum, S. Kensington. In this the dorsal markings are very rich blackish brown, the white spots more sparse; long. in size about 1 inch. Habitat., Exmouth Gulf, W. Australia, collected by T. H.

[a] *C. Peasei* (Sowb.) figured in Thes. Conch. XX., 166, 167; and a curious monstrous var. of the same, from Mauritius, is figured *Proc. Zool. Soc.* XLVI., f. 13, 14, 1878.

Haynes. Mr. J. Michael Williams has another specimen approaching this. The dorsal covering matter seems to have been twice deposited, causing a very rich effect, with partial eclipse of the round white spots. This possibly may be *C. comma* (Perry, Conch., pl. xxi., f. 5), but the plate and description are both bad, and identification difficult in consequence.

Connected with *C. cribraria*[a] are an assemblage of seven or eight species, all bearing considerable resemblance to it in the disposition of marking. Of these, *C. esontropia* (Duclos), a broader, more pyriform shell, is connected with the type by *C. Peasei* (Sowb.), which is a translucent Sandwich Island variety, appertaining to both *esontropia* and *Gaskoinii*. *C. cribellum* (Gaskoin) is a dwarfed form, with similar dorsal ornamentation. *C. fallax* (E. A. Smith) is perhaps only a fine large, more pyriform variety of *cribraria*, with smaller white spots and paler dorsal surface. *C. Gaskoinii* (Reeve), of which I possess the type specimen formerly in Mr. Gaskoin's collection, is a beautiful shell, straw-coloured marking, with clear cut ocelli, but I have very great doubt whether it be not an extreme form of *esontropia*. *C. Cumingii* (Gray)[b] is more distinct, a very graceful attenuated pyriform shape, resembling *C. Macandrei* (Sowb.), and *C. Beckii* (Gaskoin), in a greater degree than the other species. This last was included in the *Trivia* by Messrs. H. & A. Adams, owing to some strange oversight. The *cribrariæ* more nearly run into each other than do most of the sections of this genus, and though *cribraria*,

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[a] *C. Coxeni* (Brazier). (*Proc. Zool. Soc.*, 1873, pl. xlviii., f. 10). I have seen the type in the National Collection, but would hesitate before relegating it to the *cribrariæ*, as Mr. Brazier proposes, the dentition being altogether different.

[b] *C. compta* (Pease) is but a variety of *Cumingii* from the Kingsmill group (A. Garrett) and Phœnix Island (Harper Pease), a single example in each case. The dorsal sinus is branched, hinting at some malformation in the mantle, the result, however, being a beautiful little shell, now in the National Collection. *Cf.* Sowb., T. C., pl. xxxi., f. 351.

esontropia, cribellum, Gaskoinii are typically distinct, I should never be surprised at all being eventually united.

C. carneola (L.). Reeve, Conch. Icon., pl. ii., f. 19; Sowb., Thes. Conch., pl. iii., f. 11—13.

Type.—Reddish flesh colour, with four or five bands of a darker hue of the same tint, extremely variable in shape. My largest specimen 3⅛ in. long, the smallest full grown 1 inch. The sides have more or less callous deposits. Every gradation exists between the large elongate shell, the sides not thickened, and the smaller with flattened sides, resembling an *Aricia.* Teeth purple-violet. Very abundantly distributed throughout the East.

(*a*) *Loebbeckeana* (Weinkauff). Sowb., Thes., pl. 321, f. 322. No bands of colour on dorsal surface, teeth uncoloured. Mauritius. My specimen of what I think is this, is of the usual translucent deep water character of so many Mauritian shells.

(*b*) *halmaja* (var. nov.). Dorsal surface covered with greenish callous deposit of enamel. Teeth purple, base greenish. Mauritius. From coll. Gloyne, collected by M. Robillard. I have seen a larger specimen of the same variety in the Lincolne Collection of Shells, Peel Park, Salford. An almost exact resemblance to a pickled olive may be traced, suggesting the varietal name.

(*c*) *propinqua* (Garrett). I think this is only the smaller solid form. Mr. Garrett says the number of teeth is but 25 to 30, form of *arenosa.* Paumotus and Society Isles. *Cf. J. of Conch.*, 1879, p. 117.

C. Isabella (L.). This common species mainly varies in

(*a*) *controversa* (Gray). An only *apparently* sinistral shell, back with no black dashes, base broader than the type, teeth not quite so fine.

(*b*) *limpida* (var. nov.). Uncoloured, transparent. Sandwich Isles. I have likewise seen deep olive green translucent varieties, with base yellowish white, and the orange painting of the extremities almost or quite disappearing.

C. staphylæa (L.). This is the most puzzling, variable shell in the genus. Many species have been made out of it. They all run so nearly into each other as to merge into varieties. The type is grey or brown, white pustulated all over with small excrescent granules, extremities reddish brown tipped, teeth extended across the base on each side in ridges, sometimes yellow, sometimes white. Very variable in size, ·5 to ·10 inch normally, but I have a specimen 1·25 inch.

(*a*) *interstincta* (Wood). A form with pustules semi-obliterated, sometimes larger, teeth coarser and darker.

(*b*) *limacina* (Lamk.). Smooth, oblong, white spotted, teeth not extending across the centre of the columellar base, very near the last var., but the pustules quite undeveloped. I have this also pellucid from the Sandwich Isles. Colour pale straw. A sub-species, as in the next.

(*c*) *polita* (Roberts). A shorter, more brilliantly coloured pellucid shell from the Sandwich Isles, the minute white spots often obsolete except laterally, base white, teeth much as in small specimen of *limacina*. I do not know *C. Annæ* (Roberts), but suspect it to be a variety of this protean sub-species.

(*d*) *consobrina* (Garr.). Mr. Andrew Garrett (*J. of Conch.*, 1879, p. 122) has likewise described *Trivia* (*Pustularia*) *consobrina*, which he separates from *T. staphylæa*, the base being yellowish white instead of livid, and the teeth being margined with yellowish brown, hair like lines, extending quite across the face of the shell, and being more or less bifid; supplementary ones also may be observed between the primary teeth, which more or less anastomose towards the outer margins of the shell. Length 22 mm. Found rarely at the Viti and Samoa Islands, in dead, but perfect condition.

(*e*) *semiplota* (Mighels), 1848. *fimbriatula* (Sowb.), 1870. Undoubtedly synonyms. I have two specimens labelled by the latter name, in no way excepting in small size (·4 inch) differing from the smooth white spotted *limacina* (Lamk.). As Mr. Roberts suggests (Man. Conch. Cyp., p. 194) *C. spadix* (Mighels) is the immature state of this variety.

The smaller *Triviæ* have been so satisfactorily worked out by various eminent Conchologists, especially Gray and Gaskoin, as to be now almost perfectly systematized. As a rule they are fairly constant; and their differentiation is not a matter of undue difficulty, if the presence or absence of the dorsal impression or sinus, and the colour, quality and quantity of ribs, and disposition of marking be regarded.

* * * * *

Lastly, with respect to the other species and varieties of *Cypræa* proper, *e.g.* the *cervus* and *hirundo* sections, *xanthodon*, *picta* and allies, and others, complete acquiescence in, and acceptance of the diagnoses in Sowerby's "Thesaurus Conchyliorum" must be taken as valid reasons against the necessity of further alluding to them in this paper.

(XIV.) *Doubtful species.*

C. eximia (Gray), *Proc. Zool. Soc.*, 1849, is a fossil from Tasmania, very near *C. umbilicata* (Sowb.) It was supposed by Dr. J. E. Gray, the describer, to have become only recently extinct, after the fashion of *Bulimus auris-vulpina* (Chemnitz) from S. Helena,[a] which, if one can compare the causes which lead to the annihilation of a *marine* form with those affecting a *terrestrial* species, seems to have been of equally restricted range, and to have eventually died a natural death.

[a] *Cf.* Wollaston, Testacea Atlantica, p. 547. Melliss. S. Helena, p. 121, pl. xxii., f. 2, 2[1].

C. Galathææ (Reinhardt). Pet. J., 1872, p. 326. Of this I know nothing.

C. Jenningsia (Perry). Conch., pl. xix., f. 4. The following is Perry's description :—Shell of a beautiful pink colour, spotted with varied spots of a white colour, mouth paler pink, furbelowed and undulated ; two dark brown spots at each end. Unique in the cabinet of Mr. Jennings, of Chelsea.

The figure does not represent *C. guttata* (Gray), with which some writers have supposed it identical, any more than the description. It is most likely a large and highly coloured variety of *C. staphylæa* (L.).

Brief descriptions will also be found in Tryon. Man. Conch. Cyp., p. 207, of three unrecognised species.

C. castanea (Anderson).

C. parvula (Phil.). " Near *fimbriata*."

C. trigonella (Dufresne).

* * * * *

(XV.) *Enumeration of Museums, etc., consulted.*

In preparing this survey of the genus, for which I have been collecting material during the last eighteen years, besides utilizing my own specimens as much as possible, I have on many occasions been carefully through all the vast stores in the National Collection, South Kensington, where Mr. Edgar A. Smith, of the Zoological Department, and his assistant, Mr. Atkinson, have always been ready with kind help. Frequent visits have been paid to the Museum, Owens College, Manchester, where, in company with Mr. J. R. Hardy, the curator, I have thoroughly examined, classified and arranged the series of *Cypræa*, formed by the united collections of Mr. Swainson, Mr. Walton, and Mr. Cholmondeley. This contains some very interesting forms. At Peel Park Museum, Salford, through the courtesy of Mr. Plant, F.G.S., the Lincolne collection, mainly acquired in 1825 at the sale of the celebrated Cabinet of Lord Tankerville, has been investigated. I have also often visited the Liverpool Museum, where the Rev. H. H. Higgins, Mr. T. J. Moore, and especially Mr. F. P. Marrat, have laid me under much obligation. The well selected collection of cowries, belonging to Mr. J. Michael Williams of the same city, have also been inspected with much pleasure and profit; and last, but not least, Mr. G. B. Sowerby, of Fulham Road, London, has rendered me much assistance, and to him and all the above-named I would return most cordial thanks.

As opportunity offered, I have likewise inspected the Natural History Museums in Paris, Brussels, Geneva, and some other Continental cities and towns; and, in the United States, the Academies of Natural Science at New York, Boston, the Smithsonian Institution, Washington, and portion of the Philadelphian Academy Collections, on which Mr. Tryon bases his volumes; also that of Montreal, Canada.

The fine series of Australian Mollusca, collected and exhibited by Dr. J. C. Cox, of Sydney, at the Indian and Colonial Exhibition in London, during 1886, was also twice attentively examined.

The works of Messrs. Sowerby, Reeve, and Adams, and the monograph of *Cypræa* in Tryon's Manual of Conchology, by Mr. S. Raymond Roberts, have all proved of the greatest service, and I also beg to tender my acknowledgements for the aid afforded thereby.

ADDENDUM.

C. ocellata (L.). (*b*) *calophthalma* (var. nov.). Shell oblong, dorsal surface pale yellow-ochreous, eyes remarkably large and prominently painted, twice the size of the ordinary ocelli ; the base with usual markings, as in the type, but of darker brown. Figured by Sowerby, Thes. Conch., pl. xxvi., fig. 243, from the specimen till lately in the possession of the late Mr. Walton, but now incorporated with the Owens College collection, Manchester, which is the only example I have ever seen. This and the var. (*a*) present the two opposite extremes in coloration-development of *C. ocellata* (L.). Long. 1⅛ inch.

A remarkably beautiful shell. Habitat : Ceylon.

Mention of this was, by an oversight, omitted in its proper place.

ERRATA.

p. 226, l. 14, for ' this ' read ' the.'
" 22, for ' liked ' read ' like.'
p. 195, for ' mascarus ' read ' mascarene.'
p. 214, l. 21, for ' 7/16 ' read ' ⅞ ' inch.

(XVI.) LIST OF THE DESCRIBERS OF RECENT SPECIES AND VARIETIES OF THE GENUS CYPRÆA.

Adams, H. & A.
Adanson, M.
Ancey.
Anderson.
Angas G. F.
Barnes.
Beck, H.
Bernardi, A. C.
Blainville, H. M. D. de.
Born, J.
Brazier, J.
Brocchi, G.
Broderip, W. J.
Bucquoy, E.
Chemnitz, J. H.
Costa, O. G.
Cox, J. C.
Crosse, H.
Dautzenburg, P.
Deshayes, G. P.
Dillwyn, L. W.
Duclos, P. L.
Dufresne.
Dunker, W.
Fischer, P.
Garrett, A.
Gaskoin, J. S.
Gill.
Gmelin.
Gray, J. E.
Gronovius.
Higgins, E. T.
Humphrey, G.
Jousseaume, F.
Kiener, L. C.
Klein, J.
Lamarck, J. B. de.
Leathes, G.
Linnæus, Carl.
Locard, A.
Macgillivray.
Marie.
Marrat, F. P.
Martens, E. von.
Martini, F. H. W.
Martyn.
Mawe.
Melvill, J. C.
Menke, C. T.
Meusch.
Mighels, J. W.
Montagu, Colonel.
Montrouzier.
Mörch, O. A.
Olivi, G.
Owen, Hugh.
Paetel, F.
Pease, W. Harper.
Perry, G.
Petit, de la Saussaye S.
Philippi, R. A.
Pulteney.
Quoy.
Reeve, Lovell.
Reinhardt, O.
Requien, E.
Risso, A.
Roberts, S. R.
Rochbrune, A. de.
Rossiter, R.
Rumphius, G. E.
Salis-Marschlins, C. U. von.
Sars M.
Shaw.
Smith, Edgar A.
Solander, Dr.
Souverbie.
Sowerby, G. B. (sen.)
Sowerby, G. B.
Sowerby, G. B. (jun.)
Swainson, W.
Tapparone Canefri, C.
Troschel, F. H.
Tryon, G. W. (jun.)
Weinkauff, H. C.
Wood, W.

(XVII.)

A CATALOGUE

OF THE SPECIES AND VARIETIES OF

CYPRÆA [Linn. 1740—1767],

Arranged on a new circular system, in accordance with true sequence of affinity,

By JAMES COSMO MELVILL, M.A., F.L.S.

Syn. Porcellana (Rumphius), 1705. Erythræa (Barrol), 1714. Peribolus (Adanson), 1787.
Cypriarius (Dum.), 1806. Cyprea (Montf.), 1810. Trivia (Gray), 1824. Cypræovula (Gray), 1824.
Naria (Gray), 1828. Aricia (Gray), 1832. Luponia (Gray), 1832. Cyprædia (Swainson), 1840.
Pustularia (Swainson), 1840. Epona (H. & A. Adams), 1858. Gaskoinia (Roberts), 1869.

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1. C. *Valentia* (Perry), 1811.	Syn. C. princeps (Gray). Zool. Jour. I. 75, 1824.	Persian Gulf. N.Guin. (Cox).
2. C. *mappa* (Linn.) Syst. Nat. (12 Ed.), 1767.	alga Perry, 1811. montosa Rumph., 1705.	East Indies and Pacific Isles.
a. panerythra (Melv.) 1888, *cf.* Sowb., Thes. Conch., f. 28.		N. Caledonia.
b. subsignata (Melv.) ,, ,, ,, f. 24, 25, 27.		St. Brandon Shoals, &c., Paumotus Is. (Garrett).
c. nigricans (Montr.) 1875. J. de Conch. p. 220, pl. 8, f. 5.		N. Caledonia.
3. C. *aurantium* (Mart.), 1782.	Aurora (Solander), 1795. Aurora Solandri (Chemn.), 1795.	Tahiti, Friendly Isles, Loyalty Isles.
4. C. *Broderipii* (Gray). Descriptive Catalogue, 1832, p. 3.		Madagascar.
5. C. *nivosa* (Brod.). Zool. Jour. III., p. 84.		Mauritius.
6. C. *vitellus* (L.), Syst. Nat. (12 Ed.), 1767. *a.* sarcodes (Melv.), 1888.	Salita (Rumph.), 1705. dama (Humph.), 1779. subfuscula (Martyn), 1782. dama (Perry), 1811.	Eastern Seas, from E. Africa to Japan and Australia, Pacific Isles.
7. C. *camelopardalis* (Perry), 1811.	melanostoma (Leathes), 1825.	Red Sea.

8. *C. pantherina* (Solander). MSS.	Dillwyn Cat. Shells, V., p. 449, 1817.	vinosa (Gmelin), 1790. flammea (Gmel.) 1790 juv. guttata (Lam.), 1810. obtusa (Perry), 1811. tigrina (Lamk.) 1822.	Red Sea.
a. badionitens (Melv.), 1888.			,,
b. theriaca (Melv.). ,,	*cf.* Sowb., Thes. Conch., pl. 11, f. 71.		,,
c. albonitens (Melv.). ,,			,,
d. juvenca (Melv.), ,,			,,
e. syringa (Melv.), ,,			,,
9. *C. tigris* (L.) Syst. Nat. (12 Ed.), p. 1176, 1767.		leopardalis (Humph.), 1779. guttata (Rumphius), 1705. tigrina (Gmel.), 1790. pardalis (Shaw). feminea (Gmelin), 1790. ambigua (Gmelin), 1790 juv.	All Eastern Seas, rare at Moreton Bay, Australia (Coxen).
a. flavonitens (Melv.), 1888.			Fiji Isles and Mauritius.
b. hinnulea (Melv.) ,,			
c. russonitens (Melv.) ,,			
d. chionia (Melv.) ,,			
e. ionthodes (Melv.) ,,			
f. lyncichroa (Melv.) ,,			Caroline Isles, (Garrett), &c.
g. zymecrasta (Melv.) ,,			
10. *C. stercoraria* (Linn.).	Syst. Nat. p. 1174, 1767.	grummulus (Humph.) 1779. cauteriata (Chem.), 1788. fasciata (Chem.), 1788, testa juv. ? olivacea (Gmel.) 1790. nebulosa (Gmel.) 1790. conspurcata (Gm.), 1790.	West Africa.
a. gibba (Gmel.), 1790.			,,
b. rattus (Lamk.), 1822.			,,
11. *C. venusta* (Sowb.).	Ann. Mag. N. H. XIX., p. 346, 1847.	Thatcheri (Cox) 1869. roseopunctata Sb. MSS.	Dampiers Island W. Australia.
12. *C. umbilicata* (Sowb.).	Tank. Cat. p. 30, f. 7, 1825.		N. S. Wales.
a. alba (Cox).			Tasmania.
13. *C. Scottii* (Broderip).	Zool. Jour. V., 330, 1831.	Friendii (Gray) 1832.	Swan River, W. Australia.
14. *C. marginata* (Gaskoin).	Zool. Proc. 1848, p. 91.	an. var., juv. sqq. ?	South Australia.
15. *C. Thersites* (Gaskoin).	Zool. Proc. 1848, p. 90.		South Australia.
16. *C. decipiens* (E. A. Smith).	Zool. Proc. p. 482, pl. 48, 1880.		North and West Australia.
17. *C. mus* (Linn.).	Syst. Nat. p. 1176, 1767,	autumnalis (Perry) 1811.	Mediterranean, Canary Islands
a. bicornis (Sowb.).	Thes. Conch. pl. 30, f. 321, 1870.		,,
18. *C. leucostoma* (Gask.).	Zool. Proc. p. 25, f. 1843		Arabian Seas.

19. *C. moneta* (L.). Syst. Nat. p. 1178, 1767, cærulea (Perry) 1811.		Laccadives and Maldives, India, Ceylon, Philippines, E. Indies, Java, China, Japan, Australia.
a. icterina (Lam.), 1822.		,,
b. Barthelemyi (Born.), 1861.		New Caledonia.
c. atava (Rochbrune), 1884.[a]		India.
d. camelorum (Rochbr.), 1884.		W. Africa.
e. ethnographica (Rochbr.), 1884.		E. Indies.
f. mercatorum (Rochbr.), 1884.		Corsica?
g. pleuronectes (Rochbr.), 1884.		Maldive Isles.
h. plumaria (Rochbr.), 1884.		Sandwich Isles.
i. vestimenti (Rochbr.), 1884.		N. Caledonia.
20. *C. obvallata* (Lam.) (obvelata) An. sans. Vert. VII., 1822.		E. Indies, Cook, Society, and Paumotus Is. (Garrett).
a. calcarata (Melv.), 1888.		
21. *C. annulus* (Linn.). Syst. Nat., p. 1179, 1767. annularis (Perry), 1811.		,, and Australia.
a. Noumeensis (Marie), 1884.		New Caledonia.
b. Hamyi (Rochbr.), 1884.		Zanzibar.
c. Harmandiana (Rochbr.), 1884.		
d. Perrieri (Rochbr.), 1884.		
e. pura (Paetel Cat.), 1887.		Mauritius.
22. *C. caput. anguis* (Phil.). Menke and Pfr., p. 24, 1849.		Australia? Sandwich Isles?
23. *C. caput serpentis* (L.). Syst. Nat., p. 1175, 1767.	reticulum (Gmel.), 1790. albella (Lam.), 1822.	Sandwich Isles, Australia, India, Pacific.
24. *C. caput draconis* (Melvill), 1888. M. and P. Manch. Lit. and Phil. Soc., 4th Ser., Vol. I., p. 214.		Hong Kong.
25. *C. Mauritiana* (Linn.). Syst. Nat., p. 1176. 1767.	undata (Chem.), 1767. Bulla Cypræa (Gmel.), 1790 jv. regina (Gmel.), 1790 juv. turbinata (Gmelin), 1790. trifasciata (Gmel.), 1790 juv. fuliginosa (Perry), 1811 juv.	Mauritius, Borneo, Ceylon, Pacific Is., &c.
26. *C. Arabica* (L.). Syst. Nat., p. 1173, 1767.	fragilis (L.), 1767 juv. amethystea (L.), 1767. bandata (Perry), 1811 juv.	India, Pacific Islands, East Indies, Formosa (Swinhoe).
a. reticulata (Martyn), 1782.	maculata (Barnes), 1824.	India & Pacific.
b. histrio (Meusch), sp. 1787.	arlequina (Chemn.), 1790.	E. Indies.
c. intermedia (Gray), 1824.		Paumotus, Cook Isles, &c.
d. eglantina (Duclos), 1883.		New Caledonia.
e. niger (Roberts), 1885.		,,

[a] *Cf.* de Rochbrune, Monographie de Gen. *Mercatoria*, Bulletin Soc. Malacog. de France, 1884, where all these mere varieties are treated as of specific importance.

27.	*C. scurra* (Chemn.), Conch. Cat. X., p. 103, 1788.	indica (Gmel.), 1790.	Indian Ocean and Pacific Is.
28.	*C. gemmula* (Weinkauff), 1881.		Red Sea.
29.	*C. Arabicula* (Lam.). An. Sans. Vert. VII., 1822.		Mexico, Lower California.
30.	*C. punctulata* (Gray). Zool. Jour. I., p. 387, 1824.		Panama, Lower California.
31.	*C. pallida* (Gray). Zool. Jour. I., p. 387, 1824.		Hong Kong, East Indies.
32.	*C. xanthodon* (Gray). Descr. Cat., p. 10, 1832.		Australia.
33.	*C. nigropunctata* (Gray). Zool. Journ. IV., p. 81, 1828.		Gallapagos Isles
	a. irina (Kiener).[a]		,,
34.	*C. lentiginosa* (Gray). Zool. Journ. I., p. 489, 1824.		Ceylon.
35.	*C. zonata* (Chemn.). Conch. Cat. X., 1788.	maculata (Gray), 1824. Zonaria (Gmel.), 1788.	Senegambia, W. W. Africa.
	a. Surinamensis (Perry),[b] 1811.	nebulosa (Kiener), 1840.	West Indies? Gambia.
36.	*C. sanguinolenta* (Gmel.). Syst. Nat., 1790.	purpurascens (Swn.), 1823. purpurata (Solander), 1817.	Gambia.
37.	*C. picta* (Gray). Zool. Jour. I., p. 389, pl. 7, 12, f. 10, 1824.		Cape de Verde Isles and adjacent coast, W. Africa.
38.	*C. subviridis* (Reeve). Proc. Zool. Soc., 1835.		Australia and N. Caledonia.
39.	*C. errones* (L.). Syst. Nat., p. 1178, 1767.	ovata (Gmel.), 1790. ovum (Gmel.), 1790. subflava (Gmel.), 1790. oblonga (Gmel.), 1790. erronea (Gmel.), 1790. olivacea (Lam.), 1822.	Indian & Chinese Seas, Australia, and Pacific Is.
	a. chrysophæa (Melv.) 1888.		Port Blair, Andaman Isles.
	b. Coxi (Brazier). Zool. Proc., 1873, sp.		Dupuch Island, N.W. Australia,
	c. Sophiæ (Brazier). Proc. L. S. N. S. W., I. p. 7, 1875, sp.	chrysostoma (Brazier), 1880.	San Christoval Island, Solomon Is.
40.	*C. cylindrica* (Born). Mus. p. 184, 1780.	punctulata (Gmel.) 1790.	Ceylon, Philippines, Japan, Mauritius.
	a. subcylindrica (Sowb.) Thes. Conch., Cyp., pl. 27, f. 269, 270, 1870.		Ceylon, New Caledonia, Philippines.
41.	*C. hirundo* (Linn.). Syst. Nat., p. 1178, 1787.		New Caledonia, Ceylon, Australia.
	a. Rouxi (Ancey), Le Nat. No. 7, p. 55, 1882.		

[a] The variety *irina* I take to be the larger form of the species.

[b] If the reported Gulf of Mexico habitat for this sub-species be not confirmed, it would be wise to abandon the name *Surinamensis*, and revert again to that bestowed by Kiener.

42. *C. felina* (Gmel.) Syst. Nat., p. 3412, 1790.		Indian Ocean and Pacific Is.
a. ursellus (Gmel.). Syst. Nat., p. 3411, 1790.		,,
43. *C. fabula* (Kiener). Coq. Viv., p. 54, an. var. præc.?	Sowerbyi (Gray), 1832.	,,
44. *C. neglecta* (Sowb.). Conch. Ill., sp. 66, 1837.		Australia, India.
45. *C. coffea* (Sowb.). Thes. Conch., Cyp. pl. 32, 1870.		Borneo.
46. *C. Owenii* (Sowb.). Conch. Ill., sp. 64, 1837.		Mauritius.
47. *C. Menkeana* (Desh.). Conch. I. Reunion, 1863, an. var. præc.?		I. Reunion, Borneo.
a. modesta (H. Owen), 1870, *cf.* Sowb., T. C., f. 512.		I. Diego Garcia, Seychellas.
48. *C. fimbriata* (Gmel.). Syst. Nat., p. 3420, 1790.		Japan, Paumotus, and other Pacific Isles, Australia.
a. microdon (Gray). Zool. Jour., 1828, sp.		Mauritius, Ceylon, Fiji Is., &c.
b. unifasciata (Mighels). Proc. Bost. Soc. II., p. 25, 1848, sp.		Sandwich and Society Isles (Garrett).
c. macula (Adams), 1867. ut sp.	notata (Gill), 1858. an. nom. vetust. rest? irescens (Sowb.), 1870.	Japan and Australia.
d. Cholmondeleyi (Melv.), 1888, *cf.* Sowb., T. C., pl. 32. f. 387, 388.		Australia.
49. *C. irrorata* (Solander). NARIA i. (Gray), 1828.		Paumotus Archipelago, Society and Cook's Is.
50. *C. quadrimaculata* (Gray). Zool. Jour. I., p. 376, 1824.		East Indies, Fiji Isles (Garrett)
a. pallidula (Gaskoin). Zool. Proc., 1848.		?
51. *C. interrupta* (Gray). Zool. Jour. I., p. 77, 1824.		Ceylon.
a. rhinoceros (Souv.). J. de Conch., p. 156, 1865.		New Caledonia, Fiji & Samoa I.
52. *C. Rashleighana* (Melvill). Jour. of Conch. V., p. 288, 1887.		?
53. *C. teres* (Gmel.). Syst. Nat., p. 3405, 1790.	subteres (Weink.).	Ceylon, Society and Paumotus Is. (Garrett).
54. *C. tabescens* (Solander). Dillwyn Cat. I., 1817.	cylindrica (Wood), 1828. (teres Gmel.?) in part.	N. Caledonia. Tropical Australia, East Indies, Pacific.
a. latior (Melv.) 1888, *cf.* Reeve, Conch. Icon. XIV., 66a, 1845.		
b. pellucens (Melv.) 1888.		Sandwich Isles.
c. alveolus (Tapparone Canefri), J. de Conch. XXX., p. 30.		Mauritius.
d. elaiodes (Melv.) 1888.		,,

55. *C. caurica* (Linn.).	Syst. Nat., p. 1179, 1767.	dentex (Humph.), 1779. dracæna (Born), 1780. corrosa (Gron.), 1783. stolida (Gmel.), 1790. derosa (Gmel.), 1790.	E. Indies, Pacific Isles, Australia (Coxen).
a. oblongata (Melv.), 1888.		elongata (Perry), 1811. ?	East Indies, Hindostan, Ceylon, Australia.
b. concava (Hugh Owen), 1870.			Mauritius.
c. obscura (Rossiter).			New Caledonia.
56. *C. cruenta* (Gmelin).	Syst. Nat., p. 3420, 1790.	morbillosa (Sol.), 1817. variolaria (Lam.), 1822. cruentata (anct. var.).	E. Indies, Pacific Is. rare (Garrett)
a. coloba (Melvill), 1888.			,,
57. *C. stolida* (L.).	Syst. Nat., p. 1180, 1767.	rubiginosa (Gmelin), 1790.	Ceylon, Borneo, Philippines, Fiji.
a. moniontha (Melv.), 1888.			,,
b. diauges (Melv.), 1888.			Mauritius.
c. gelasima (Melv.) 1888.			,,
d. Crossei (Marie), 1884.			New Caledonia.
58. *C. brevidentata* (Sowb.), sp.	Thes. Conch., 1870.	an. var. præc.?	Borneo.
59. *C. Erythræensis* (Beck).	Reeve, Conch. Icon., pl. 14, f. 63, 1845.		Red Sea to Zanzibar.
60. *C. Barclayi* (Reeve).	Zool. Proc., p. 208, pl. 38, f. 4, 1857.		San Diego, I. Mauritius.
61. *C. pulchella* (Swn.).	Phil. Mag. 61, p. 376, 1823.		China Seas.
62. *C. pyriformis* (Gray).	Zool. Journ. I., p. 371, 1824.		Ceylon, N. Australia.
a. Smithi (Sowb.),	Zool. Proc., 1881, pl. 56, f. 8.		
63. *C. Bregeriana* (Crosse),[a] 1868.	J. de Conch. XVI., p. 277.		New Caledonia.
64. *C. Walkeri* (Gray).	Desc. Cat., p. 10, 1832.		Philippines, New Guinea (Braz.).
a. amabilis (Jousseaume), 1881.			
65. *C. lynx* (L.).	Syst. Nat., p. 1176, 1767.	chinensis (Gmel.), 1790. leucostoma (Gmel.), 1790. squalina (Gmel.), 1790. Vanelli (L.), 1767, test. juv.	G. of Suez, Natal, Australia, Eastern Seas, all Pacific Is., India, &c.
a. Caledonica (Crosse), 1869.			N. Caledonia.
b. Williamsi (Melv.), 1888.			N. Borneo.
66. *C. Saulæ* (Gaskoin).	Zool. Proc., p. 23, 1843.		Philippines. Elphinstone Is. (Chall. Exped), Peel I., Moreton Bay (Braz.).
67. *C. gracilis* (Gaskoin).	Zool. Proc., p. 93, 1848.		I. Bourbon, China Seas, (Samarang Voyage).

[a] Although usually attributed a variety of *Walkeri*, perhaps Weinkauff and Paetel are correct in assigning specific rank to this shell. As previously observed, a form nearly allied to this will shortly be described by Mr. E. A. Smith, from N. W. Australia.

68. C. *Goodalli* (Gray). Descrip. Cat. Cyp. 1832.		Lord Hood's Is.
a. fuscomaculata (Pease). Zool. Proc., 1865.		I. Apaian, Fiji, Tonga Isles, Pacific.
69. C. *Adelinæ* (Roberts).	fuscomaculata (Gray), 1870.	?
70. C. *contaminata* (Gray). Descrip. Cat., Cypræa, 1832.		E. Ind. Islands.
71. C. *punctata* (L.). Mantissa, p. 548, 1771.	atomaria (Gmel.), 1790.	Philippines, Pacific Isles.
a. stercus muscarum (Lam.), 1822.		,,
b. trizonata (Sowb.), 1880.		?
72. C. *clandestina* (Linn.). Syst. Nat., p. 1177, 1767,	pusilla (Gmel.), 1790. moniliaris (Lam.), 1822.	Ceylon, Pacific I. Australia.
a. candida (Pease), Zool. Proc., 1865.		?
? *b.* Artuffeli (Jousseaume). Bull. Soc. Zool., France, 1876.		?
c. passerina (Melv.), 1888.		?
d. aberrans (Ancey), Le Nat., 1882.		?
73. C. *asellus* (L.). Syst. Nat., p. 1178, 1767.	vespa (Rees, Cycl.).	Australia, Fiji, and E. Indies.
74. C. *diluculum* (Reeve).[a] Conch. Icon. XIV. 65, 1845.	undata (Lam.), in part, 1822. ziczac (Dillwyn).	Mauritius, Bourbon, Philippine Isles.
75. C. *ziczac* (L.). Syst. Nat., p. 1177, 1767.	undulata (Wood), 1828. misella (Perry), 1811. lineata (Gmel.), 1790.	Ceylon, Mozambique, West Africa.
76. C. *lutea* (Gronov.). Zoophyl. fascic. 3, pl. 19, 1781.	nivea (Mawe), 1828. commixta (Mawe), 1828.	N. S. Wales. L. Macquarie (Angas, Brazier).
a. Humphreysii (Gray). Zool. Journ. I., 1824.		,,
77. C. *Comptoni* (Gray). Jukes' Voy. II., p. 356, 1847.		S. Australia.
78. C. *angustata* (Gmel.). Syst. Nat., p. 3421. 1790.	maculata (Perry), 1811.	S. Australia and Tasmania.
79. C. *declivis* (Sowb.). Thes. Conch. III., 1870.		Victoria, Australia.
80. C. *piperita* (Solander). Zool. Journ. I., p. 498, 1824 (Gray).		Australia.
a. bicolor (Gaskoin), Zool. Proc., 1848.		Australia and Sandwich Isles (Mus. Brit.).
81. C. *pulicaria* (Reeve). Zool. Proc., p. 23, 1846.		Australia.
82. C. *edentula* (Sowb.). Cl. Ills. sp. 102, 1837.	Gaskoinia edentula (Roberts).	C. G. H.
83. C. *Algoensis* (Gray). Zool. Journ. I., p. 498, 1824.		Algoa Bay, S. Africa.
84. C. *similis* (Gray). Zool. Miscell., p. 26, 1844.		C. G. H.
a. castanea (Higgins). Zool. Proc., p. 78, 1868, sp.		,,
85. C. *fuscodentata* (Gray). Zool. Jour. I., p. 499, 1864.		,,
86. C. *amphithales* (Melvill), 1888. M. and P. Manch. Lit. and Phil. Soc., 4th Series, Vol I., p. 221.		Port Elizabeth, S. Africa.
87. C. *Capensis* (Gray) [CYPRÆOVULA]. Zool. Jour. III., p. 573, 1828.		C. G. H.
88. C. *Adamsonii* (Gray). Desc. Cat. Cyp., p. 7, 1832.		I. Capul, Philippines, Tahiti, Society & Paumotus I., Pacif.

[a] Mr. Lovell Reeve's reasons for altering the name *undata* to *diluculum* may be found in his Conch. Icon. The former title was first given to another species, in part only, and confused by Linnæus, thus necessitating the suppression of the Lamarckian name.

[Subgen. TRIVIA (Gray). sp. 89—140.]

89.	*C. pustulata* (Lam.) [PUSTULARIA.] An. du Mus. XV., 1810.		Panama.
90.	*C. Madagascariensis* (Gmelin).[a] Syst. Nat., p. 3419, 1790.		Honolulu, Sandwich Isles.
	a. granulata (Pease), 1862.[b]		Central Pacific (H. Pease).
91.	*C. nucleus* (Linn.). Syst. Nat., p. 1181, 1767.	gemmosa (Perry) 1811. cerea (L.).	Philippine Isles, Pacific Isles, Mauritius, &c.
92.	*C. radians* (Lam.). An. Sans Vest. VII., 1822.		St. Elena, West Columbia, Ecuador.
	a. rota (Weinkauff), 1881.		Panama.
93.	*C. Solandri* (Gray). Conch. Ill., sp. 128, 1837.		California.
94.	*C. costis punctata* (Gaskoin). Sowb., Thes. Conchyl., 1870.		,,
95.	*C. Californica* (Gray). Zool. Jour. III., p. 365, 1827.		,,
96.	*C. depauperata* (Sowb.). C. Ill., sp. 130, 1837.		,,
97.	*C. Maugeræ* (Gray). Descr. Cat. Cyp., p. 13, 1832.		Gallapagos Isles.
98.	*C. sanguinea* (Gray). Descr. Cat. Cyp., p. 14, 1832.	lathyrus (Dufresne), 1826.	California and S. American Coasts.
99.	*C. pisum* (Gaskoin). Zool. Proc., p. 24, 1846.		Ceylon.
100.	*C. pediculus* (Linn.) Syst. Nat., p. 1180, 1767.	picturata (Mörch), 1877. sulcata (Dillwyn), 1887.	Florida, West Indies.
	a. labiosa (Gask.), 1835.		
	b. cimex (H. Owen), 1870.		
101.	*C. fusca* (Gray). Desc. Cat., Cyp., p. 15, 1832.		Gallapagos Isles
102.	*C. suffusa* (Gray). Desc. Cat., Cyp., p. 16, 1832.	C. armandina (Duclos).	West Indies.
	a. pullata (Hugh Owen), 1879.		,,
103.	*C. Pacifica* (Gray). Desc. Cat., Cyp., p. 15, 1832.		G. of California & Gallapagos Isles.
104.	*C. quadripunctata* (Gray).[c] Zool. Jour. I., p. 376, 1824.	rotunda (Kiener), 1840.	W. Indies and G. of Mexico.
105.	*C. exigua* (Gray). Desc. Cat., Cyp., p. 15, 1832.	C. tremeza (Duclos), 1833. C. gemmula (Gould), 1845.	Sandwich Isles and New Caledonia.
	a. corrugata (Pease), 1868.[d]		

[a] *Madagascariensis* is an entire misnomer. No specimen has been ever found in Madagascar, and custom alone sanctions its continuance. Such a name as *Honoluluensis* would be preferable in every way. It is surely not intended that errors should be perpetuated by too strict an adherence to the laws of priority.

[b] According to Mr. Pease, *granulata* is intermediate between Nos. 90 and 91. I consider the extremes perfectly distinct and always to be recognised, but have not seen this variety.

[c] Four specimens of a larger, bright pink, unspotted variety I lately detected in the National Collection, labelled as from St. Elena, W. Columbia, but there may be some mistake as to this locality.

[d] Var. *corrugata* (Pease) is considered specific by Mr. Andrew Garrett (J. of Conch. II., 122), it differs in having fewer and stronger ribs; some specimens I have pure white, in the type there is crimson suffusion of colouring.

106. *C. acutidentata* (Gaskoin).	Zool. Proc., p. 201, 1835.		Bay of Guayaquil, Ecuador.
107. *C. subrostrata* (Gray).	Zool. Jour. III., p. 363, 1827.		West Indies.
108. *C. producta* (Gaskoin).	Zool. Proc., 1835, p. 200, 1848.		Borneo, S. Africa, Australia.
109. *C. paucilirata* (Sowb.)	Thes. Conch., Cyp., No. 175*, 1870.		?
110. *C. rubinicolor* (Gaskoin).	Zool. Proc., p. 200, 1835.		Ceylon, Borneo.
111. *C. affinis* (Marrat.)	Ann. Mag. N. H. XX., 1867.		? W. Indies.
112. *C. rubescens* (Gray).	Zool. Proc., p. 185, 1832.		Gallapagos Isles
113. *C. formosa* (Gaskoin).	Zool. Proc., p. 198, 1835.		C. G. H.
a. multilirata (Sowb.), 1870.			Adriatic Sea.
114. *C. Europæa* (Montagu).	Test. Brit. Supp., p. 88, 1808.	pediculus (Mont.), 1803.	Europe, Medn., Great Britain.
a. arctica (Solander), 1803.			European Seas.
b. bullata (Pulteney), 1803.			,,
c. candida (Gill), 1843.			,,
d. coccinella (Lamk.), 1822.			,,
e. diaphana (Montagu), 1808.			,,
f. globulosa (Wood), 1828.			,,
g. Mediterranea (Risso), 1826.			,,
h. Norvegica (Sars), 1845.			,,
i. sphærica (Lam.), 1810.			,,
j. sulcata (Dillwyn), 1817, an. C. pediculi forma?			,,
k. umbilicaris (Costa), 1845.			,,
l. Jousseaumei (Locard), 1886.			,,
115. *C. Napolini* (Duclos).	Coq. Viv., p. 144, pl. 53, f. 3.	obscura (Gask.), 1848.	Cape de Verde, Senegal, &c.
116. *C. Australis* (Lamk.)	An. Sans. Vest. VII., p. 404, 1822.	rosea (Duclos), 1838.	S. Australia.
117. *C. pulla* (Gaskoin).	Zool. Proc. 1846, p. 24.	1848, p. 97.	Gallapagos Isles.
118. *C. pulex* (Solander).	Zool. Jour. III., MSS. 1827.	lachrymalis (Mk.), 1828. rosea (Requien), 1848.	Corsica (Salis Schwabe), Meditn. Sea, Azores.
119. *C. oniscus* (Lamk.)	Ann. du Mus. XVI., p. 103, 1810.	aperta (Swn.), 1828. ,, (Mawe), 1835.	C. G. H.
120. *C. ovulata* (Lamk.).	Ann. Sans. Vest. VII., p. 398, 1822.		,,
121. *C. vesicularis* (Gaskoin).	Zool. Proc., p. 203, 1835.		,,
122. *C. costata* (Gmel.).	Syst. Nat., p. 3418, 1790.	triticea (Dufr.), 1826. carnea (Gray), 1828. rosea (Wood), 1828.	,, ? and W. Indies (Krebs sec. Roberts).
123. *C. sulcata* (Gaskoin).	Zool. Proc., p. 95, 1848.	Gaskoinii (Roberts), 1869.	Philippine Islds.

124.	*C. vitrea* (Gaskoin). Zool. Proc., p. 95, 1848.		Philippines.
125.	*C. globosa* (Gray). Descr. Cat. Cyp., p. 14, 1832.	pilula (Kiener). 1840. sphærula (Mighels), 1848.	W. Indies, Australia, Sandwich Isles, Society and Paumotus Isles.
126.	*C. candidula* (Gaskoin). Zool. Proc., p. 200, 1835.	approximans (Beck), 1835. olorina (Duclos), 1835.	E. Atlantic. Mexico.
127.	*C. brevissima* (Sowb.). Thes. Conch. Cyp., No. 168, 1870.		?
128.	*C. pellucidula* (Gaskoin). Zool. Proc., p. 23, 1846.		Pacific Ocean.
129.	*C. nivea* (Gray). Desc. Cat. Cyp., p. 15, 1832.	scabriuscula (Kiener), 1840.	West Indies.
130.	*C. oryza* (Lamk.). Ann. du Mus. XVI., p. 104, 1810.	pediculus (L.) in part., 1767.	Sandwich Isles. Philippines. Society Isles (Garrett).
131.	*C. grando* (Gaskoin). Zool. Proc., p. 96, 1848.		Manila, Philippines.
		hordacea (Kiener), 1840.	
132.	*C. insecta* (Mighels). Proc. Bost. Soc. II., p. 24, 1845.		Sandwich and Pacific Isles, Australia.
133.	*C. cicatrosa* (Sowb.). Thes. Conch., No. 160, 1870.		?
134.	*C. scabriuscula* (Gray). Zool. Jour. IV., p. 1827.	intermedia (Kien.), 1840. Sandwichensis (Sowb.), 1870.	E. Indies.
135.	*C. margarita* (Sol. MSS.). Zool. Jour. IV., p. 87, 1828.		Annaa I., Society and Paumotus Isles, South Pacific Ocean.
136.	*C. annulata* (Gray). Zool. Jour. IV., p. 88, 1829.		Mauritius and Philippine Is., Fiji, Pacific Is.
137.	*C. Childreni* (Gray). Zool. Jour. I., p. 518, 1824.		Borneo, Philippines, N. Caledonia, Pacific.
		C. affinis (Gmel.), 1790.	
138.	*C. globulus* (L.). Syst. Nat., p. 1161, 1767.		Mauritius, Borneo, New Caledonia, Pacific Isles.
139.	*C. cicercula* (L.). Sys. Nat., p. 1181, 1767.		Borneo.
	a. Lienardi (Jouss.), 1874.		Mauritius.
	b. tricornis (Jouss.), 1874.		,,
140.	*C. staphylæa* (L.). Syst. Nat., p. 1181, 1797.	granulata (Humph.), 1779. striata (Gmelin), 1790.	E. Indies, all Pacific Islds.
	a. interstincta (Wood), 1828.	Jenningsia (Perry), 1811?	Pacific Islands.
	b. limacina (Lamk.), 1822.		E. Indies, Fiji, Samoa I.
	c. polita (Roberts), 1868.		Sandwich Isles.
	d. consobrina (Garrett), 1879.		Fiji and Samoa.
	e. semiplota (Mighels), 1848.	Annæ (Roberts), 1868. fimbriatula (Sowb.)., 1870. Spadix (Mighels), 1848.	Sandwich Isles. ,, ,,

141. *C. helvola* (L.) Syst. Nat., p. 1180, 1767.	chalcedonia (Perry), 1811. citrina (Kien.), 1840. derosa (Risso.) stellata (Humph.), 1779. albella (Lam.), 1822.	E. Indies.
a. Mascarena (Melv.) 1888.		Mauritius.
b. argella (Melv.), 1888.		E. Indies.
c. Hawaiiensis (Melv.), 1888, *cf.* Sowb., T. C., pl. 25, f. 217.		Sandwich Isles.
142. *C. citrina* (Gray). Zool. Jour. I., p. 509, 1824.		Ceylon, North W. Australia, Mauritius.
143. *C. Thomasi* (Crosse), J. de Conch. XIII., p. 57, 1865.		?
144. *C. spurca* (L.). Syst. Nat., p. 1179, 1767.	flaveola (Lam.), 1822. lota (L.), 1709. acicularis (Gmel.), 1790.	Mediterranean, Canary Isles.
a. cernica (Sowb.), Thes. Conch. Cyp., 1870 sp.		Mauritius.
b. Verdensium (Melv.), 1888.		C. de Verde Isles
145. *C. cribraria* (L.). Syst. Nat., p. 1178, 1767.	comma (Perry), 1811.	Ceylon, North Ireland.
a. translucida (Melv.), 1888.		Mauritius.
b. Exmouthensis (Melv.), 1888.		Exmouth, Gulf, W. Australia.
c. fallax (E. A. Smith) an. sp.?		West Australia.
146. *C. cribellum* (Gaskoin). Zool. Proc. p. 22, 1849.		Mauritius.
147. *C. esontropia* (Duclos). Mag. de Zoologie, p. 26, 1833.		Philippines, Cook & Kingsmill Is.
a. Peasei (Sowb.).[a]		Sandwich Isles.
b. Coxeni (Cox). an. sp. ?[b]		Solomon Isles.
148. *C. Gaskoinii* (Reeve). Zool. Proc., p. 23, 1846.		Cook, Society, and Paumotus Isles.
149. *C. Cumingii* (Gray). Desc. Cat., Cyp., 1832.		Society Isles.
a. compta (Pease). Zool. Proc., 1860.		Kingsmill Group. (A. Garrett).
150. *C. Macandrei* (Sowb.). Thes. Conch., Cypr., 1870.	an. var. sqq. ?	Red Sea.
151. *C. Beckii* (Gaskoin). Zool. Proc., p. 205, 1835.		,,
152. *C. flaveola* (L.). Syst. Nat., p. 1179, 1767.	labiolineata (Sowb.), 1870. poraria (Mart.), 1768. scabiosa (Humph.), 1779.	Australia, Japan
a. labrolineata (Gaskoin), 1848.	Helenæ (Roberts), 1868.	?
153. *C. gangrenosa* (Solander MSS.). Dilwynn Cat. I., 1817.	*Reentsi* (Dkr.)	Ceylon, China, &c.
a. Boivinii (Kiener). Coq. Viv.		E. Africa.
b. Reentzii (Dkr.)., an. syn. præc. var. ?		
c. melanosema (Melv.), 1888.		Mauritius.

a Perhaps *Peasei* should be relegated to the next, *C. Gaskoinii*, but the varieties of both species run closely into each other, and it is almost impossible to draw a hard and fast line of demarcation.

b As mentioned in the text, I am not sure where this shell should be placed. Perhaps near *erronea*. The dentition differs from the *cribrariæ* in being more strongly extended across the base.

154.	*C. erosa* (L.). Syst. Nat., p. 1179, 1767.	similis (Gmelin), 1790. stellata (Perry), 1811. fasciata (Perry), 1811.	Indian Seas, all Pacific Islands.
	a. phagedaina (Melv.), 1888, *cf.* Sowb., T. C., pl. 18, f. 113.		,,
	b. chlorizans (Melv.), 1888.		,,
	c. straminea (Melv.), 1888, *cf.* Sowb., T. C., pl. 18, f. 110.		Mauritius.
	d. nebrites (Melv.), 1888, *cf.* Sowb., T. C., p. 18, f. 114, 115.		N. Borneo.
155.	*C. ocellata* (L.). Syst. Nat., p. 1180, 1767.		Ceylon, India.
	a. palatha (Melv.), 1888.		?
	b. calophthalma (Melv.), 1888, *cf.* Sowb., T. C., pl. 26, f. 243.		Ceylon.
156.	*C. Listeri* (Gray). Zool. Jour. I., p. 507, 1824.		Philippine Isles.
157.	*C. poraria* (Linn.). Syst. Nat., p. 1180, 1767.		Fiji Isles. New Caledonia, all Pacific Islands.
	a. Kauaiensis (Melv.), 1888.		I. Kauai, Sandwich Is.
158.	*C. albuginosa* (Mawe). Zool. Jour. I., p. 510, 1824.		G. of California.
159.	*C. ovata* (Perry), 1811, Conch. XXI., 3,	turdus (Lam.), 1822. pardalina (Dunker), 1852.	Straits of Sunda, Persian Gulf.
	a. nivea (Gray).		,,
	b. pyriformis (Sowb.), *cf.* Sowb., Thes. Conch., pl. 28, 284.		Red Sea.
160.	*C. Lamarckii* (Gray). Zool. Jour. I., 1824.		E. Indies.
	a. redimita (Melv.), 1888.		,,
161.	*C. eburnea* (Barnes). Ann. Lyc. N. H. I., p. 133, 1824.		Philippine Isles, Fiji (Garrett).
		lactea (Wood), 1838.	Stradbroke Is., Moreton Bay (Brazier).
162.	*C. miliaris* (Gmel.). Syst. Nat., p. 3420, 1790.		Japan. N. S. Wales, Philippines.
	a. magistra (Melv.), 1888.		Japan.
163.	*C. guttata* (Gray). Zool. Jour. I., p. 511, 1824.		China? N.S.W.? Red Sea?
164.	*C. bicallosa* (Gray). Conch. Illus., sp. 50, 1837.		I. St. Vincent, W. I.
	a. ingloria (Crosse), 1878.		Africa?
	b. Aubreyana (Jousseaume), 1869.		I. St. Vincent, W. I.
165.	*C. pyrum* (Gmel.) Sys. Nat., p. 3411, 1790.	fulva (Gmel.), 1790. Siciliana (Salis), 1793. rufa (Lam.), 1822. variolosa (Gmel.) maculosa (Gmel.), 1790. cinnamomea (Oliv.). pumilio (Burg.). flavescens (Born).	Mediterranean Sea, Algeria, and Morocco.
	a. Petitiana (Crosse & Fischer), J. de Conch. XX., p. 213, 1872.		Senegal.

166. C. *Sowerbyi* (Kiener).[a] Coq. Viv., p. 38, 1840.	ferruginosa (Kiener). maculata (auct. in part).	G. of California (Roberts).
167. C. *onyx* (Linn.). Syst. Nat. p. 1177, 1767.	pulla (Gmelin), 1790.	Zanzibar, Ceylon, Borneo.
a. succincta (Linn.), 1767.		
b. adusta (Chem.). Conch. Cat. X., 1790.		,,
c. carnicolor (Duclos), 1835.	nympha (Duclos).	Philippines.
168. C. *spadicea* (Swainson). Phil. Mag. LXI., p. 376, 1823.		San Diego, California.
169. C. *Hungerfordi* (Sowerby). Proc. Zool. Soc., 1888.		Hong Kong.
170. C. *physis* (Brocchi). Conch. foss., II., p. 284, 1814.	Grayi (Kiener), 1840.	Mediterranean Sea.
a. achatidea (Gray). C. Ill., f. 179, 1837.		,,
171. C. *chrysalis* (Kien.). Coq. Viv., 92, 1840.		?
172. C. *Isabella* (L.) Syst. Nat., p. 1177, 1767.		E. Indies and Pacific.
a. controversa (Gray). Zool. Jour., I., p. 144.		,, California ? (Stearns).
b. limpida (Melv.), 1888.		Sandwich Isles.
173. C. *testudinaria* (L.) Syst. Nat., p. 1173, 1767	testudinosa (Perry), 1811.	Ceylon, India. Pacific Islands.
174. C. *Argus* (L.) Syst. Nat., p. 1173, 1767.		E. Indies and N. Caledonia, Samoa, Fiji, Tonga, and Kingsmill Is.
175. C. *cervus* (L.) Mantissa, p. 548, 1771.	atheroma (Mensch), 1787. cervina (Lam.), 1822. oculata (Gmel.), 1790.	Cent. America, Panama ? (Roberts.) E. Indies. (Reeve and Sowb.).
176. C. *exanthema* (L.). Syst. Nat., p. 1172, 1767	exanthemata (Perry), 1811. zebra (L.), plumbea (Gmel.), 1790.	G. of Mexico, etc. Key West, Florida, J.C.M.
(*a*) cervinetta (Kien.), Coq. Viv., p. 74.	leucopis (Shaw).	West Indies. Mazatlan. Panama.
177. C. *exusta* (Sowb.). Conch. Illus., sp. 25, 1837.	dubia (Gmel.), 1790. bifasciata (Gmel.), 1790.	Red Sea.
178. C. *talpa* (Linn.). Syst. Nat., p. 1174, 1767.		Pacific and E. Indies, Pacific.

[a] I have an interesting dwarf stunted and broad form of this species, base dark fawn, spots and markings as in the type.

179.	*C. pulchra* (Gray). Zool. Jour., I., p. 380, 1824.	pulchella (Gray), 1824.	Red Sea.
180.	*C. lurida* (L.). Syst. Nat., p. 1175, 1767.	Kunthii (And.), 1828. leucogaster (Gmel.), 1790. minima (Dkr.), 1853.	Mediterranean Sea.
181.	*C. ventriculus* (Lamk.). An. du Mus. XVI., p. 452, 1810.	carneola (Martyn), 1782. Achatina (Dillwyn), 1817.	I. Annaa, &c. Pacific Ocean.
182.	*C. carneola* (L.). Syst. Nat., p. 1174, 1767.	crassa (Gmel.), 1788. contrastriata (Perry), 1811. Otaheitensis (S. & W.), 1829. Sowerbyi (Anton), 1839. marmorata (Blainville), 1826.	Pacific Islands. Indian Ocean.
	a. Lœbbeckeana (Weinkauff), 1881.		Mauritius.
	b. halmaja (Melv.), 1888.		New Caledonia.
	c. propinqua (A. Garrett), 1879. I. of C., p. 116, 117.		Paumotus and Society Isles.
183.	*C. tessellata* (Swn.). Zool. Jour. I., p. 150, 1824.		Sandwich Isles. New Zealand?
184.	*C. clara* (Gask.) Zool. Proc., p. 13, 1851.		?
185.	*C. cinerea* (Gmel.). Syst. Nat., 1790.	albida (Gmel.), 1790. livida (Gmel.), 1790. purpurescens (Gmel.), 1790. rufescens (Gmel.), 1790. translucens (Gmel.), 1790. stellata (Gmel.), 1790. sordida (Lam.), 1822. cincta (Sol.), 1824.	Antilles. Pernambuco (Challenger Exped.)
186.	*C. Reevei* (Gray). Conch. Illus., f. 52, 1837.		Swan River, W. Australia.
187.	*C. arenosa* (Gray). Zool. Jour. I., 1824.		Pacific Islands.
	a. alba (Gray).		I. Annaa.
188.	*C. sulcidentata* (Gray). Zool. Journ. I., 1824.		Australia and Sandwich Is.
	a. xanthochrysa (Melv.), 1888,[a] *cf.* Sowb. T.C., pl. 4, f. 23.		Sandwich Is.
189.	*C. leucodon* (Broderip). Zool. Journ. IV., p. 163, 1828.		?

DOUBTFUL SPECIES.

C. castanea (Anders). Archives für Nat. II., 1837.	
C. Galathææ (Reinh.)	
C. Jenningsia (Perry). Conch., pl. 19, f. 4, 1811.	
C. parvula (Philippi.). Zeit. für Malak., 1869.	
C. trigonella (Dufresne), 1826.	New Holland.

[a] Shell as in type, but of warm fulvous yellow colour. A noteworthy colour variety, from the Sandwich Islands, and of rare occurrence there.

EXPLANATION OF PLATES

I., II.

1, 1[a]. *C. caput draconis* (Melvill).

2, 2[a]. *C. caput serpentis* (L.).

3. *C. Rashleighana* (Melvill).

4. *C. stolida* (L.) var. *moniontha.*

5. *Do.* var. *diauges.*

6. *C. miliaris* (L.) var. *magistra.*

7. *C. cruenta* (Gmel.) var. *coloba.*

8. *C. caurica* (L.) var. *oblongata.*

9. *Do.* dwarf var.

10. *C. erosa* (L.) var. *straminea.*

11. *Do.* var. *phagedaina.*

12. *Do.* var. *chlorizans.*

13. *Do.* var. *nebrites.*

14. *C. ocellata* (L.) var. *palatha.*

15. *C. fimbriata* (Gmel.) var. *Cholmondeleyi.*

16. *C. Lamarckii* (Gray) var. *redimita.*

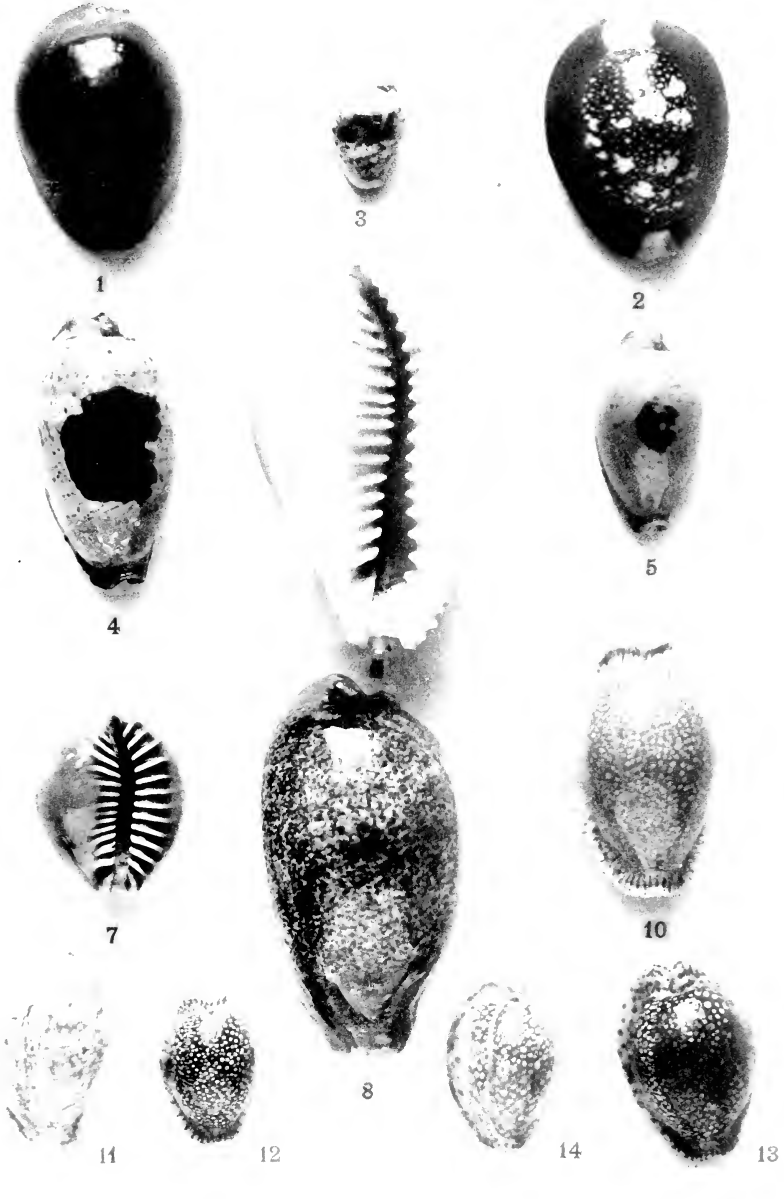
17. *C. guttata* (Gray).

18. *C. Helvola* (L.) var. *Hawaiiensis.*

19. *C. amphithales* (Melvill).

20. *C. Capensis* (Gray).

21. *C. Algoensis* (Gray).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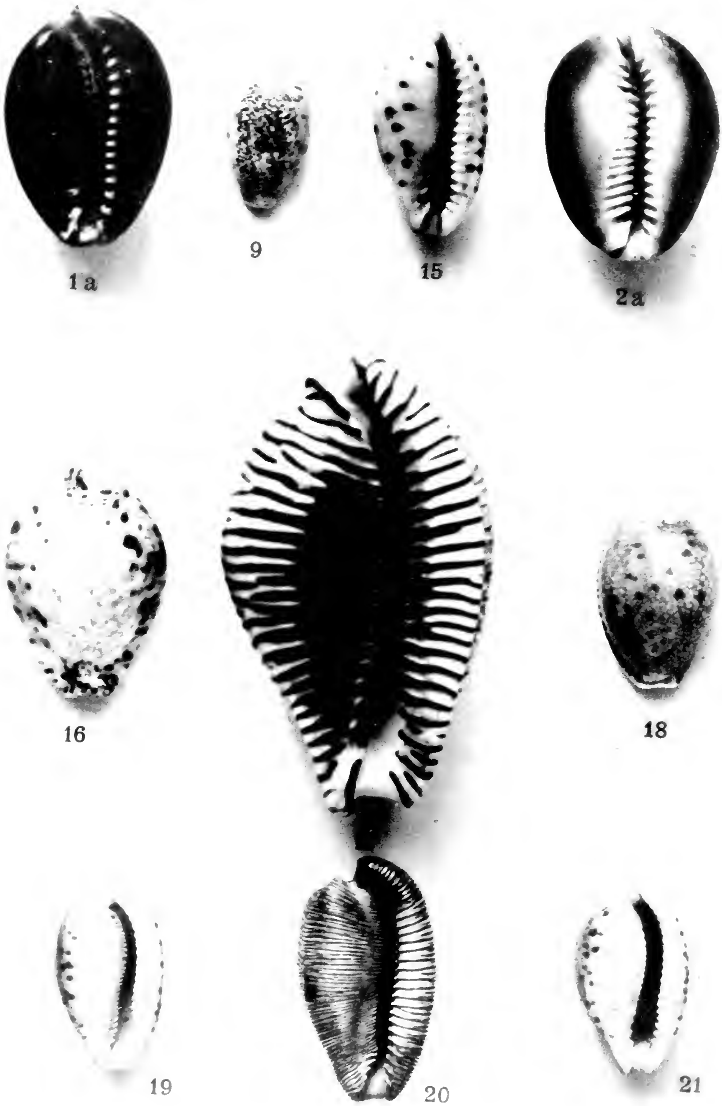
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Memoir of the late Professor Balfour Stewart, LL.D., F.R.S. By Professor A. Schuster, Ph.D., F.R.S., F.R.A.S.

(Received April 25, 1888).

Balfour Stewart was born on November 1st, 1828. He went to school at Dundee, but entered St. Andrews University at the age of thirteen, and from there passed on to Edinburgh, where he studied under Professor Forbes. Leaving College when he was eighteen years old he was sent by his parents to serve his apprenticeship in business with a firm at Leith, and afterwards went out to Australia with a cousin, James Balfour, to start on a commercial career. But he was never fond of business and soon returned home to Edinburgh, where he became assistant to Prof. Forbes in 1853. In 1859 he was appointed Director of the Kew Observatory, and held this post until 1870, when he was appointed Professor of Physics at the Owens College, Manchester. He died of apoplexy, on December 19th, 1887, at Ballymagarvey, near Drogheda, where he had gone to spend the Christmas holidays.

Balfour Stewart's name was first prominently brought before the public by his researches on Radiant Heat. His paper was presented to the Royal Society of Edinburgh, and read on March 10th, 1858.

Stewart's claim, as one of the founders of the theoretical basis of spectrum analysis, rests on the experiments and reasoning contained in this paper. To appreciate the work done by Stewart we must realise what was known and generally recognised at the time his experiments were made. Those interested in the subject will find an account of the early history of Prevost's theory of exchanges by Stewart himself, in the Reports of the British Association for 1861. In this report he summarises the results of his own experiments as follows.

1. The radiating power of thin polished plates of different substances was found to vary as their absorptive power, so that the radiation of a plate of rock salt was only 15 per cent of the total lampblack radiation for the same temperature.

2. It was shown that the radiation from thick plates of diathermanous substance is greater than that from thin plates, no such difference being manifested when the substances are athermanous.

3. It was found that heat, radiated by a thin diathermanous plate, is less transmissible through a screen of the same material as the heated plate than ordinary or lampblack heat, this difference being very marked in the case of rock salt.

4. Lastly, heat from a thick diathermanous plate is more easily transmitted through a screen of the same nature as the source of heat than that from a thin plate.

The conclusions drawn from these experiments are now generally recognised. Kirchhoff, somewhat later than Stewart, fully proved them from thermodynamical principles, and gave a more definite meaning to the terms radiation and absorption. In view of the great importance, which now attaches to the science of Spectrum Analysis, a few words are necessary to explain the difference between Stewart's and Kirchhoff's treatment. Stewart proved that the streams of radiant heat crossing any point of an enclosure of uniform temperature, are not altered by the interposition of a body whether opaque or transparent; and this, as the author shows, is easily explained on the theory that, when equilibrium of temperature is established, any body or part of a body radiates as much heat as it gains. The radiation crossing any point is made up of heat which has passed through different thicknesses of the transparent bodies in various directions. What Stewart established for the sum of these streams, Kirchhoff proved for each of them individually. The reasoning thus becomes much more complicated, but the proof more complete and definite.

In other words: Stewart had shown that the law of equality between radiation and absorption could explain all phenomena. Kirchhoff went further and proved that the law is the only one which can account for the facts. The existence of internal radiation was completely established by Stewart's researches, and he also considered the connexion between internal radiation and refractive indices. Considering the problem at first only as one of two dimensions, he took the internal radiation to be proportional to the refractive index, but later corrected the result and concluded, as was also done by Kirchhoff, that when three dimensions are taken into account, the intensity of internal radiation must vary as the square of the refractive index. Although Stewart generally speaks only of the sum of all thermal radiation, he shows that the laws he deduces must be true for each individual wave length. From this there was only one step to the complete generalisation of spectrum analysis. He has told the author of this notice, how he tried an experiment which was to lead him still further in the same direction. Salt was placed in a spirit flame and the yellow flame was looked through a plate of rock salt. Believing the yellow colour of the flame to be due to luminous *salt*, he expected the rock salt to absorb an appreciable quantity of the light, which, however, was found not to be the case. We now know that salt is decomposed in the flame and that the yellow flame is due to luminous sodium vapour, which explains the failure of Stewart's experiment.

In February, 1860, Stewart communicated to the Royal

Society of London a paper (*Proc. Roy. Soc.*, X., p. 385) in which a number of experiments on radiant light were described. It was mentioned that the amount of light radiated by coloured glasses is in proportion to their depth of colour, transparent glass giving out very little light; also that the radiation from red glass has a greenish tint, while that from green glass has a reddish tint. It was also shown that when black and white porcelain is heated in the fire, the black parts give out much more light than the white, thereby producing a curious reversal of the pattern.

In another paper (*Proc. Roy. Soc.* X.) an experiment was described showing that tourmaline, which absorbs the ordinary ray so that the transmitted light is polarised, radiates the same ray in excess when hot, but that when the heated tourmaline is viewed against an illuminated background of the same temperature as itself, this peculiarity disappears.

The *Proceedings of the Roy. Soc.* (XI., p. 193) contain a short theoretical note on the internal radiation in uniaxial crystals, in which the different refractive indices in different directions are considered.

Another important problem connected with the theory of radiation occupied Stewart's mind, and led to a joint experimental investigation with Professor P. G. Tait. When all bodies in an enclosure through which no heat is allowed to pass are at rest, we know that equilibrium of temperature establishes itself. But this is no longer necessarily true when one of the bodies is in motion. A body whose particles are vibrating in the same period will, when in rapid motion, appear to send out rays of different refrangibilities, according as it is viewed from the front or from behind. Similarly its absorptive properties will be altered. It is not quite easy to see what relations must hold between absorption and radiation, in order that a body may retain the same temperature whether at rest or in motion. Stewart and Tait tried to solve the problem by experiment, and published their results in three papers, "On the heating of a disk by rapid rotation in vacuo." (*Proc. Roy. Soc.*, XIV., p. 90 and 339; XV., p. 290).

They have summed up the results of their experiments as follows:—

1. There is a temporary heat or cold effect which may be supposed to arise in particles very slightly attached to the disk; this is radiated off chiefly during rotation, and probably does not greatly affect the disk afterwards.

2. There is a surface gas effect, which in an aluminium, and even in an ebonite disk, is conducted into the interior as it arises, so that it does not greatly radiate during rotation of the disk. In a paper disk, however, which is formed of a badly conducting material loosely put together, part of the effect does escape as radiation during rotation.

3. There is a residual effect which is more deeply seated than the gas effect. And in as much as radiation takes place from a perceptible depth, this effect is much more influential than the gas effect in increasing radiation after rotation. In the case of a paper disk, this deeply seated effect will be less diminished by radiation during rotation than the gas effect, and therefore after rotation in such a disk we might expect the gas effect to be peculiarly small.

During the latter part of Stewart's life his attention was chiefly devoted to meteorology, terrestrial magnetism and solar physics. While at Kew, the important question of accurate temperature measurements presented itself, and gave rise to a series of experiments on the air thermometer. The results are published in the Transactions of the Royal Society (*Phil. Trans.*, 1863). A paper "On the melting point of Paraffin," published in the *Proceedings* of this Society (XII., 1873) originated in the want felt by him of a standard point of temperature between that of freezing and of boiling water.

The subject of Terrestrial Magnetism is a great loser by Stewart's death. He felt the necessity not only of making observations, but also of reducing and discussing them. In a complicated subject like this, any discussion must be founded on some preliminary hypothesis which commends itself to the author's mind. Some writers in publishing their result, prefer to give only what they consider strictly proved, and to keep back the hypothesis which has served them as a stepping stone. But it is doubtful whether the method followed, for instance, by Faraday, in which the scientific public is taken into the author's confidence, and in which the author's train of thought is made clear, is not of greater ultimate advantage to science. It must always depend on the personal temperament of the author which of these methods he adopts, and Stewart preferred always to put forward what he called his "working hypothesis." His ideas on the nature of the forces which produce magnetic disturbances have changed but little from the year 1861 to the time of his death. The earth itself and earth currents only acted, in his opinion, in a secondary way, while the primary current producing the disturbance takes place in the upper regions of the atmosphere. He concludes his first paper on the subject (*Proc. Roy. Soc.* XI.) by putting forward the hypothesis that earth currents and auroras are due "to the fluctuating nature of this primary current" (by induction), while "the magnetic disturbances are due to its absolute intensity." The various facts which have come to light since 1862 have not materially altered in his opinion, except in so far that in his later writings he seems to ascribe a greater importance to earth currents in producing magnetic disturbances. In connexion with Mr. Sidgreaves, Stewart compared the simultaneous changes of declination during disturbances at Kew and Stonyhurst, and came to the conclusion that the ratio between the magnitudes of such changes was not constant, but depended to some extent upon the abruptness of the disturbance. The

Rev. S. J. Perry, Director of the Stonyhurst Observatory, has since paid considerable attention to this point, and in joint communication with Balfour Stewart, some preliminary results are given (*Proc. Roy. Soc.* XXXIX., p. 363, 1885).

The conclusions of the investigation are given in these words :—

(1) In the very great majority of cases the angular value the declination disturbance is greater for Stonyhurst than for Kew.

(2) The ratio $\frac{S}{K}$ is certainly greater for disturbances of short than for those of long duration. Our observations are not, however, sufficiently extensive to enable us to represent this ratio graphically as a function of the duration.

(3) As far as we can tell from a limited number of observations the value of the above ratio does not depend on the magnitude of the disturbance.

I now turn to that part of Stewart's work in which he was principally interested at the time of his death, namely, the phenomena of sunspots and their connexion with planetary configurations and terrestrial meteorology.

In a paper published jointly with Dr. Warren de la Rue and Mr. Benjamin Loewy, the size of a sun spot or group of spots is investigated in its passage across the solar disk, in order to determine whether the size varied as some meridian opposite one of the planets is traversed. Definite results were obtained for the planets Mercury and Venus; the average size of a spot in both cases being smallest on that side of the sun which is directly under the planet, and largest 180° away from that point. As regards Venus the result appears both from the observation of Carrington and those taken at Kew.

The question of a possible connexion between the temperature range at Kew and the phases of the moon is discussed at length in a paper (*Proc. Roy. Soc.*, XXV., p. 102, 1877), and the result seems decidedly in favour of such a connexion, especially in the winter months. During the period 1855–65, as well as during the succeeding ten years, the temperature range, which is the difference between the highest and lowest value of temperature during any given day, shows a minimum at full moon, and a maximum shortly after new moon. It is strange, however, that the researches of Baxendell (*Proc. Man. Lit. and Phil. Soc.*, Session 1879), from observations taken at Southport, have led to a directly opposite result. Baxendell does not give his calculations as interfering in any way with Stewart's result, but rather as tending to show that the influence may be different at different places. It is easy to see, in fact, that if the lunar influence affects, in the first place, the distribution of pressure over the globe, so that the path of atmospheric depressions is altered, an increase of temperature range at one place might be coincident with a decrease at another. Nevertheless, the marked difference in behaviour between two places not further apart than Kew and Southport, show the desirability of further researches; and now that a connexion between the frequency of thunderstorms and the phases of the moon has been shown to exist by Koeppen and others, the subject no doubt will receive renewed attention.

The daily range of magnetic declination is a quantity similar to that of the daily range of temperature, and Stewart has frequently taken it as the basis for his reductions. The daily range exhibits also a lunar period having a maximum both at full and new moon (*Proc. Roy. Soc.* XXVI, 1877). A similar result had been previously obtained by Mr. Capello, the Director of the Lisbon Observatory.

The same paper contains another investigation.

The sun spot variation which apparently depends on planetary configuration suggested a search for a similar variation of declination range. It appeared from the result that during conjunction of Mercury and Venus both sun spots and declination range showed an increased range, but the smallest range coincided with a difference of 90° between the positions of the two planets. The relative position of Mercury and Jupiter gave a maximum of declination range shortly after conjunction, and a minimum shortly after opposition. As regards the position of Mercury, a maximum and minimum declination range nearly coincided with perihelion and aphelion. In two further papers (*Proc. Roy. Soc.* XXVII., p. 81 and 389, 1878) the same results are deduced from the declination ranges of Trevandrum and Prague.

Balfour Stewart has, in connexion with others, spent much labour on the discovery of certain short-period inequalities in terrestial and solar phenomena. Fourrier has taught us how a series of observations, however irregular, may, by a purely analytical process, be represented by a series of harmonic oscillations; there are an infinite number of ways in which this can be done by varying the length of time within which we wish to represent the series. But the amplitudes and phases of the oscillations thus deduced have no prophetic virtue, that is to say, from the observations taken within certain limits we can tell nothing as to what will happen outside those limits. If on the other hand we have reason to believe that our series of observations is actually formed by the superposition of certain definite oscillations, which are due to real but unknown causes, we may have to deduce the periodicities of these causes, and this is a different and much more difficult process. Balfour Stewart has described a method (*Proc. Roy. Soc.*, Vol. XXIX., p. 1, 1879) by means of which this can be done, and has applied the method of a number of problems. It is an inherent difficulty of this, as of any other method, that results deduced from a single series do not give us any certain results. Accidental regularities, such as we must expect, can only be eliminated by a repetition of the work, on different sets of observations. Wherever a repetition was possible, Stewart did not spare any pains to repeat his laborious calculations, but no one was better aware than himself, how much remained to be done in that direction. The following are the results which he deduced from a preliminary investigation in which he was assisted by Mr. W. Dodgson.

1. The temperature ranges at Kew, Utrecht, and Toronto exhibit certain common periods (around 24 days).

2. Of the curves embodying those periods, that of Kew is most like the mean, and that of Toronto least so.

3. Similar phases appear to occur at Toronto 8 days before they occur at Kew, and occur at Kew one day before they occur a Utrecht.

4. Correcting for these differences of phase, the individual inequalities at Kew, Utrecht, and Toronto are very like the mean of the three and like each other.

5. Of these, the Kew inequalities are most like the mean, the Toronto least so.

6. The declination ranges at Kew and Prague exhibit certain common periods which we may regard as the same, or very nearly the same, as the meteorological periods above indicated.

7. Similar magnetic phases appear to occur at Kew about one day before they occur at Prague.

8. Correcting for this difference of phase, the individual inequalities at Kew and Prague are very like the mean of the two, and like each other.

9. There is also a less striking likeness between the various magnetical and the corresponding meteorological inequalities.

10. Provisional sun spot records appear to show certain solar inequalities, very like the magnetic and meteorological inequalities in point of period.

The connexion between temperature range and sun spot areas is further discussed in a paper written jointly with Mr. W. L. Carpenter (*Proc. Roy. Soc.*, Vol. XXXVII., p. 1, 1884). The authors describe the results of their calculation as follows:

α. Sun spot inequalities around 24 and 26 days, whether apparent or real, seem to correspond closely in period with terrestrial inequalites as exhibited by the daily temperature range at Toronto and at Kew.

β. While the sun spot and the Kew temperature range inequalities present evidence of a single oscillation, the corresponding Toronto temperature range inequalities present evidence of a double oscillation.

γ. Setting the inequalities as we have done, the sun spot maximum occurs about eight or nine days after one of the Toronto maxima, and the Kew maximum about seven days after the same Toronto maximum.

δ. The proportional oscillation exhibited by the temperature range inequalities is much less than that exhibited by the corresponding solar inequalities.

They add: "It must be borne in mind that the truth of a connexion between celestial and terrestrial phenomena can only be decided by cumulative evidence of various kinds.

"What we claim to have here done is to have given reasons for supposing that there is a correspondence in time scale, and a definite relation in type and phase between sun spot and temperature range inequalities."

Similar results are obtained from a comparison by the same authors between apparent inequalities of short period in sun spot areas and diurnal declination ranges at Toronto and Prague.

The sun spot period, with its average duration of about eleven years, shows very great irregularities both in the length and amplitude of the oscillation. Stewart has shown (*Mem. Manc. Lit. and Phil.*) that from the year 1780 to 1870 the curve of solar activity can be best represented as a superposition of three oscillations, one of ten-and-a-half, one of twelve, and a minor one of about sixteen years. The irregularities would thus be produced by the beats of these three fluctuations. It will be interesting to see how far further observation will confirm this result.

It was in great part owing to Balfour Stewart's influence that a Committee of the British Association was formed at the Canada meeting, "to consider the best means of comparing and reducing magnetic observations." He was appointed secretary to the committee which has already presented three valuable reports. They contain among other matters a research jointly with Mr. Lant Carpenter on the connexion between magnetic disturbances and the strength of the wind. A good case is made out from the conclusion that high and low disturbance values of magnetic force correspond with, and slightly precede, high and low wind values.

Balfour Stewart was the author of several text-books. His "Primer of Physics," as well as his "Elements of Physics," are well established as sound and clear elementary works. His book on heat is an excellent treatise, and his "Lessons in Elementary Practical Physics," written jointly with Mr. W. W. Haldane Gee, is the most complete composition of experimental methods in physics which has been written. An admirable treatise on the "Conservation of Energy," forms one of the volumes of the International Science Series. Students of Terrestrial Magnetism will for a long time to come value the clear and, at the same time full account he has given of the present state of the subject in the last edition of the "Encyclopædia Britannica." His book "The Unseen Universe, or Physical Speculations on a Future State," by Stewart and Tait, was published anonymously at first. It went rapidly through several editions, and in the fourth the authors' names were given.

The following abstract from the preface to the first shows the aim of the book.

"Forgetful of the splendid example shown by intellectual giants like Newton and Faraday, and aghast at the materialistic statements now-a-days freely made (often professedly in the name of science), the orthodox in religion are in somewhat evil case.

"As a natural consequence of their too hastily reached conclusion that modern science is incompatible with Christian doctrine, not a few of them have raised an outcry against science itself. This result is doubly to be deplored, for there cannot be a doubt that it is calculated to do mischief not merely to science but to religion.

"Our object, in the present work, is to endeavour to show that the presumed incompatibility of science and religion does not exist. This, indeed, ought to be self-evident to all who believe that the Creator of the universe is Himself the Author of Revelation. But it is strangely impressive to note how very little often suffices to alarm even the firmest of human faith."

Balfour Stewart was an active member—at one time the President—of the Psychical Society; believing that every subject must gain by an impartial and philosophical inquiry, and that no subject is beneath the attention of scientific men.

He received the Rumford medal of the Royal Society in 1868. At the time of his death he was President of the Physical Society of London, and of the Manchester Literary and Philosophical Society.

The following list of papers published by Balfour Stewart does not pretend to be quite complete, but it is believed that none of his more important contributions have been omitted.

List of Papers by Prof. Balfour Stewart.

1. On certain laws observed in the mutual action of sulphuric acid and water. *Brit. Ass. Rep.*, 1855. *Edinb. Roy. Soc. Proc.* III., 1857.
2. On the adaptation of the eye to the nature of the rays which emanate from bodies. *Victoria Trans. Phil. Soc.* I., 1855.

3. On the influence of gravity on the physical condition of the Moon's surface. *Victoria Trans. Phil. Soc.* I., 1885.
4. Description of an instrument for registering changes of temperature. *Roy. Soc. Proc.* VIII., 1856-57.
5. On a proposition in the theory of numbers. *Edinb. Roy. Soc. Trans.* XXI., 1857.
6. An account of some experiments on radiant heat, involving an extension of Prévost's Theory of Exchanges. *Brit. Ass. Rep.*, 1858. *Edinb. Roy. Soc. Trans.* XXII., 1861.
7. On some results of the Magnetic survey of Scotland in the years 1857 and 1858, undertaken by the late John Welsh. *Brit. Ass. Rep.*, 1859.
8. An account of the construction of the self-recording magnetographs at present in operation at the Kew Observatory. *Brit. Ass. Rep.*, 1859.
9. On radiant heat. *Brit. Ass. Rep.*, 1859.
10. On the light radiated by heated bodies. *Roy. Soc. Proc.* X., 1859-60.
11. Description of an instrument combining in one a maximum and minimum. Mercurial Thermometer, invented by Mr. James Hicks. *Roy. Soc. Proc.* X., 1860.
12. On the nature of the light emitted by heated tourmaline. *Roy. Soc. Proc.* X., 1859-60.
13. Note regarding Mr. Ponton's Paper "On certain Laws of Chromatic Dispersion." *Phil. Mag.* XX., 1860.
14. On the radiative powers of bodies with regard to the dark or heat-producing rays of the spectrum. *Phil. Mag.* XX. 1860.
15. On internal radiation in uniaxial crystals. *Roy. Soc. Proc.* XI., 1860-62.
16. On the great magnetic disturbance of 28th August to September, 1859, as regarded by photography at the Kew observatory. *Roy. Soc. Proc.* XI., 1860-62.
17. On the theory of exchanges and its recent extension. *Brit. Ass. Rep.*, 1861.
18. Researches on radiant heat. *Edinb. Roy. Soc. Trans.* XXII., 1861.

19. Note on the occurrence of flint implements in the drift. *Phil. Mag.* XXIII., 1862.
20. On the nature of those red protuberances which are seen on the sun's limb during a total eclipse. *Phil. Mag.* XXIV., 1862.
21. On the nature of the forces concerned in producing the greater magnetic disturbances. *Phil. Trans.*, 1862.
22. On the connexion between temperature and electrical resistance in the simple metals. *Edinb. Roy. Soc. Proc.* IV., 1862.
23. On the magnetic disturbance which took place on the 14th December, 1862. *Roy. Soc. Proc.* XII., 1862-3.
24. An account of experiments on the elastic force of a constant volume of atmospheric air, between 32° F. and 212° F., and also on the temperature of the melting point of mercury. *Phil. Trans.*, 1863.
25. On the forces concerned in producing magnetic disturbances. *Roy. Inst. Proc.* IV., 1868.
26. On the sudden squalls of 30th October and 21st November, 1863. *Roy. Soc. Proc.* XIII., 1863.
27. On the radiation and absorption of gases. *Phil. Mag.* XXVI., 1863. *Annales de Chimie.* I., 1864.
28. On the large sun spot period of about 56 years. *Astron. Month.*, Not. XXIV., 1864.
29. On the earth-currents during magnetic calms, and their connexion with magnetic changes. *Edinb. Roy. Soc. Trans.* XXIII., 1864.
30. On sun spots and their connexion with planetary configurations. *Edinb. Roy. Soc. Trans.* XXIII., 1864. *Edinb. Roy. Soc. Proc.* V., 1866.
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33. On the change in the elastic force of a constant volume of dry atmospheric air, between 32° F. and 212° F., and on the temperature of the freezing point of mercury. *Phil. Mag.* XXVII., 1864.

34. On radiant light and heat. *Quarterly Journ. Sci.* I., 1864.
35. On the sudden Squalls of 30th October and 21st November, 1863. *Roy. Soc. Proc.* XIII., 1864.
36. Remarks on sun spots. *Roy. Soc. Proc.* XIII., 1864. *Phil. Mag.* XXVIII., 1864.
37. On the velocity of propagation, between Oxford and Kew, of atmospheric disturbances. *Brit. Meteor. Soc. Proc.* II., 1865.
38. On Mr. Cook's observation of the solar spectrum. *Phil. Mag.* XXXI., 1866.
39. On the latest discoveries concerning the sun's surface. *Roy. Inst. Proc.* IV., 1886.
40. On the existence of a material medium pervading space. *Roy. Soc. Proc.* IV., 1866.
41. Researches on solar physics. First series. On the nature of sun spots. *Amer. Journ. of Sci.* XLIII., 1867.
42. Researches on solar physics. Second series. Area-measurement of the sun spots observed by Carrington during the seven years from 1854-1860 inclusive, a deduction therefrom. *Amer. Journ. of Sci.* XLIII., 1867.
43. On the errors of aneroids at various pressures. *Brit. Ass. Rep.* XXXVII., 1867.
44. Note on the secular change of magnetic dip as recorded at the Kew Observatory. *Roy. Soc. Proc.* XV., 1867. *Phil. Mag.*, XXXI.
45. On the specific gravity of mercury. *Roy. Soc. Proc.* XV., 1867. *Phil. Mag.* XXXI.
46. A comparison between some of the simultaneous results of the barographs at Oxford and at Kew. *Roy. Soc. Proc.* XV., 1867.
47. Description of an apparatus for the verification of sextants designed and constructed by T. Cooke, and recently erected at the Kew Observatory. *Roy. Soc. Proc.* XVI., 1868.
48. An account of certain experiments on aneroid barometers, made at Kew Observatory, at the expense of the Meteorological Committee. *Roy. Soc. Proc.* XVI., 1868. *Smithsonian Rep.*, 1868. *Phil. Mag.* XXXVII., 1869.

49. Remarks on meteorological reductions, with especial reference to the element of vapour. *Brit. Ass. Rep.* XXXIX, 1869.
50. On the sun as a variable star. *Roy. Inst. Proc.* V., 1869.
51. A preliminary investigation into the laws regulating the peaks and hollows exhibited in the Kew magnetic curves for the first two years of their production. *Roy. Soc. Proc.*, XVII., 1869.
52. On auroral appearances and their connection with the phenomena of terrestrial magnetism. *Astron. Soc. Month. Not.*, 1870. *Phil. Mag.* XXXIX., 1870.
53. Results of the monthly observations of dip and horizontal force made at the Kew Observatory, from April, 1863, to March, 1869, inclusive. *Roy. Soc. Proc.*, 1870.
54. On the temperature-equilibrium of an enclosure in which there is a body in visible motion. *Brit. Ass. Rep.* XLI., 1871. *Manchester Lit. & Phil. Soc. Proc.* X., 1871.
55. Récents progrès de la physique cosmique. *Revue Cours Scient.* I., 1871.
56. An account of some experiments on the melting point of paraffin. *Manchester Lit. & Phil. Soc. Proc.* XII., 1873.
57. On ethereal friction. *Brit. Ass. Rep.* XLIII., 1873.
58. On an instrument for measuring the direct heat of the sun. *Manchester Lit. & Phil. Soc. Mem.* VI., 1875.
59. On the variations of the daily range of atmospheric temperature as recorded at the Kew Observatory. *Roy. Soc. Proc.* XXV., 1876.
60. On the variations of the daily range of atmospheric temperature as recorded at the Kew Observatory. *Roy. Soc. Proc.* XXV., 1877.
61. On the variations of the daily range of the magnetic declination as recorded at the Kew Observatory. *Roy. Soc. Proc.* XXVI., 1877.
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65. On the connexion between the state of the sun's surface and the horizontal intensity of the earth's magnetism. *Roy. Phil. Proc. Soc.* XXXIV., 1882.

66. On the long-period inequality in rain-fall. *Manchester Lit. & Phil. Soc. Mem.* VII., 1880.

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1886, Feb. 9.	Baker, John Gilbert, F.R.S. *Kew.*
1886, Feb. 9.	Berthelot, Prof. Marcellin, For. Mem. R.S. *Paris.*
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1887, April 19.	Cornu, Professor Alfred. *Ecole Polytechnique, Paris.*
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1888, April 17.	Dewalque, Gustave, Professor of Geology. *University of Liège.*
1860, Mar. 9.	Frankland, Edward, Ph.D., M.D., LL.D., D.C.L., V.P.C.S. F.R.S., Cor. Mem. Inst. Fr. (Acad. Sci.), &c. *The Yews, Reigate Hill, Reigate.*
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1881, April 17. Hittorf, Johann Wilhelm, Professor of Physics. *Polytechnicum, Münster.*

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1866, Jan. 23. Hofmann, A. W., Ph.D., M.D., LL.D., F.R.S., Cor. Mem. Inst. Fr. (Acad. Sci.), &c. 10, *Dorotheenstrasse, Berlin.*

1869, Jan. 12. Huggins, William, LL.D., D.C.L., F.R.S., F.R.A.S., Cor. Mem. Inst. Fr. (Acad. Sci.). 90, *Upper Tulse Hill, Brixton, London, S. W.*

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1887, April 19. Lockyer, Norman, F.R.S., Cor. Mem. Inst. Fr. (Acad. Sci.). *Science School, Kensington.*

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1872, April 30. Sachs, Julius, Ph.D. *Würzburg.*

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1868, April 28. Tait, Peter Guthrie, M.A., F.R.S.E., &c., Professor of Natural Philosophy, Edinburgh. 38, *George Square, Edinburgh.*

1851, April 22. Thomson, Sir William, M.A., D.C.L., LL.D., F.R.S.S. L. and E. Prof. of Nat. Phil. in Univ. of Glasgow. For. Assoc. Inst. Fr. (Acad. Sci.), &c. *2, College Glasgow.*

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1871, Nov. 8. Dale, Richard Samuel, B.A. 1, *Chester Terrace, Chester Road.*
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1878, Nov. 26. Davis, Joseph. *Engineer's Office. Lancashire and Yorkshire Railway, Hunt's Bank.*
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1886, Mar. 9. Dodgshon, John. *Kingstone Road, Didsbury.*

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1886, Feb. 9. Gee, W. W. Haldane, B.Sc. *The Owens College.*
1881, Nov. 1. Greg, Arthur. *Eagley, near Bolton.*
1874, Nov. 3. Grimshaw, Harry, F.C.S. *Thornton View, Clayton.*
1888, Feb. 7. Grimshaw, William. *Stoneleigh, Sale.*
1875, Feb. 9. Gwyther, R. F., M.A., Fielden Lecturer in Mathematics, Owens College. *The Owens College.*

1887, Feb. 21. Hall, Alfred Daniel, *Hulme Grammar School, Alexandra Park.*
1878, April 30. Harland, William Dugdale, F.C.S. 25, *Acomb Street, Greenheys*, and 48, *King Street, Manchester.*
1862, Nov. 4. Hart, Peter. *Messrs. Tennants & Co., Mill Street, Clayton, N., Manchester.*
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1884, Jan. 8. Hopkinson, Charles. 29, *Princess Street.*

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1884, Jan. 8. Hurst, Charles Herbert. *The Owens College.*

1888, April 17. Hutton, James Arthur. *Victoria Park, Rusholme.*

1870, Nov. 1. Johnson, William H., B.Sc. 26, *Lever Street.*

1878, Nov. 26. Jones, Francis, F.R.S.E., F.C.S. *Grammar School.*

1885, Dec. 1. Jones, Henry, B.A. *Norman Road, Rusholme.*

1842, Jan. 25. Joule, James Prescott, D.C.L., LL.D., F.R.S., F.C.S., Hon. Mem. C.P.S., and Inst. Eng. Scot., Corr. Mem. Inst. Fr. (Acad. Sc.) Paris, and Roy. Acad. Sc. Turin. 12, *Wardle Road, Sale.*

1886, Jan. 12. Kay, Thomas, J.P. *Moorfield, Stockport.*

1852, Jan. 27. Kennedy, John Lawson. 47, *Mosley Street.*

1862, April 29. Knowles, Andrew. *Swinton Old Hall, Swinton.*

1886, Mar. 9. Lamb, Horace, M.A., F.R.S., Professor of Mathematics at the Owens College. 106, *Palatine Road, Didsbury.*

1884, Jan. 8. Larmuth, Leopold. 96, *Mosley Street.*

1863, Dec. 15. Leake, Robert, M.P. *The Dales, Whitefield.*

1884, April 15. Leech, Daniel John, Professor, M.D. *The Owens College.*

1850, April 30. Leese, Joseph. *Messrs. S. & E. Leese, Fylde Road Mill, Preston.*

1884, Jan. 22. London, Rev. Herbert, M.A. *Pocklington, Yorkshire.*

1857, Jan. 27. Longridge, Robert Bewick. *Yew-Tree House, Tabley, Knutsford.*

1870, April 19. Lowe, Charles, F.C.S. *Summerfield House, Reddish, Stockport.*

1866, Nov. 13. McDougall, Arthur, B.Sc. *Clifton Lodge, Gore Street, Greenheys.*

1859, Jan. 25. Maclure, John William, M.P., F.R.G.S. *Whalley Range.*

1875, Jan. 26. Mann, John Dixon, M.D., M.R.C.P. Lond. 16, *St. John Street.*

1879, Dec. 2. Marshall, Arthur Milnes, M.A., M.D., D.Sc., F.R.S., Professor of Zoology, Owens College. *The Owens College.*

1864, Nov. 1. Mather, William. *Iron Works, Salford.*

1873, Mar. 18. Melvill, James Cosmo, M.A., F.L.S. *Kersal Cottage, Prestwich.*

1879, Dec. 30. Millar, John Bell, M.E., Assistant Lecturer in Engineering, Owens College. *The Owens College.*

1881, Oct. 18. Mond, Ludwig, F.C.S. *Winnington Hall, Northwich.*

DATE OF ELECTION.

1861, Oct. 29. Morgan, John Edward, M.D., M.A., F.R.C.P. Lond., F.R. Med. and Chir. S., Professor of Medicine in the Victoria University. 1, *St. Peter's Square.*

1873, Mar. 4. Nicholson, Francis, F.Z.S. 62, *Fountain Street.*

1862, Dec. 30. Ogden, Samuel. 10, *Mosley Street West.*
1884, April 15. Okell, Samuel, F.R.A.S. *Grange Road, Bowdon.*
1861, Jan. 22. O'Neill, Charles, F.C.S., Corr. Mem. Ind. Soc. Mulhouse 72, *Denmark Road.*
1844, April 30. Ormerod, Henry Mere, F.G.S. 5, *Clarence Street.*

1861, April 30. Parlane, James. *Rusholme.*
1876, Nov. 28. Parry, Thomas, F.S.S. *Grafton House, Ashton-under-Lyne.*
1881, Nov. 29. Peacock, Richard, M.P., M. Inst. C.E. *Gorton Hall, Manchester.*
1885, Nov. 17. Phillips, Henry Harcourt, F.C.S. 18, *Exchange Street.*
1854, Jan. 24. Pochin, Henry Davis, F.C.S. *Bodnant Hall, Conway.*

1854, Feb. 7. Ramsbottom, John, M. Inst. C.E. *Fernhill, Alderley Edge.*
1859, April 19. Ransome, Arthur, M.A., M.D., Cantab., F.R.S., M.R.C.S. 1, *St. Peter's Square.*
1888, Feb. 21. Rée, Alfred, Ph.D., F.C.S. 121, *Manchester Road, Middleton.*
1869, Nov. 16. Reynolds, Osborne, LL.D., M.A., F.R.S., M. Inst. C.E., Professor of Engineering, the Owens College. *Ladybarn Road, Fallowfield.*
1883, April 3. Rhodes, James, M.R.C.S. *Glossop.*
1880, Mar. 23. Roberts, D. Lloyd, M.D., F.R.S. Ed., F.R.C.P. (London). *Ravenswood, Broughton Park.*
1860, Jan. 24. Roberts, Sir William, M.D., B.A., F.R.S., F.R.C.P., Lond. 89, *Mosley Street.*
1864, Dec. 27. Robinson, John, M. Inst. C.E. *Atlas Works, Great Bridgewater Street.*
1858, Jan. 26. Roscoe, Sir Henry Enfield, B.A., LL.D., D.C.L., F.R.S., F.C.S., M.P. 64, *Queen's Gate, London.* 108, *High Street, Chorlton-on-Medlock.*

1851, April 29. Sandeman, Archibald, M.A. *Garry Cottage, near Perth.*
1870, Dec. 13. Schorlemmer, Carl, LL.D., F.R.S., F.C.S. *The Owens College.*
1842, Jan. 25. Schunck, Edward, Ph.D., F.R.S , F.C.S. *Kersal, Manchester.*
1873, Nov. 18. Schuster, Arthur, Ph.D., F.R.S., F.R.A.S. *The Owens College.*
1881, Nov. 29. Schwabe, Edmund Salis, B.A. 41, *George Street.*
1886, Oct. 5. Sidebotham, George William, M.R.C.S. *Hyde.*
1886, April 6. Simon, Henry, C.E. *Darwin House, Didsbury.*
1876, Nov. 28. Smith, James. 35, *Cleveland Road, Crumpsall.*
1859, Jan. 25. Sowler, Thomas 24, *Cannon Street.*
1884. Jan. 8. Swanwick, Frederick Tertius, M.A. *The Owens College.*

DATE OF ELECTION.

1884, Mar. 18. Thompson, Alderman Joseph. *Riversdale, Wilmslow*

1873, April 15. Thomson, William, F.R.S.E., F.C.S., F.I.C. *Royal Institution.*

1860, April 17. Trapp, Samuel Clement. 88, *Mosley Street.*

1879, Dec. 30. Ward, Thomas. *Brookfield House, Northwich.*

1873, Nov. 18. Waters, Arthur William, F.G.S. *Care of Mr. J. West, Microscopical Society, King's College, London.*

1857, Jan. 27. Webb, Thomas George. *Glass Works, Kirby Street, Ancoats.*

1859, Jan. 25. Wilde, Henry, F.R.S. *The Hurst, Alderley Edge.*

1859, April 19. Wilkinson, Thomas Read. *Manchester and Salford Bank, Mosley Street.*

1874, Nov. 3. Williams, William Carleton, B.Sc., Professor of Chemistry. *Firth College, Sheffield.*

1888, April 17. Williams, E. Leader, M.I.C.E. *Bowdon, Cheshire.*

1887, April 19. Williamson, J. H. R. 14, *St. Ann's Square.*

1851, April 29. Williamson, William Crawford, LL.D., F.R.S., Professor of Botany, The Owens College, M.R.C.S. Engl., L.S.A., For. Mem. Swed. Acad. *Egerton Road, Fallowfield.*

1860, April 17. Woolley, George Stephen. 69, *Market Street.*

1863, Nov. 17. Worthington, Samuel Barton, M. Inst. C.E. 12, *York Place, Oxford Street.*

1865, Feb. 21. Worthington, Thomas, 40, *Brown Street.*

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