THURSDAY, JULY 29, 1886

ELECTRIC TRANSMISSION OF ENERGY

Electric Transmission of Energy. By Gisbert Kapp, C.E. (London: Whittaker and Co., 1886.)

SINCE the invention of the electric telegraph the subject of the electric transmission of energy is that subject which of all others has most attracted the attention of practical scientific men. Under this head are comprehended every form of telegraph and of telephone, electric railways, and the electric transmission of power for the driving of lathes and other machines. Even the novel apparatus which has been described for enabling us to see what is happening at distant places and the very transmission of light itself through the interstellar ether must be regarded as parts of the great subject which Mr. Kapp has undertaken to treat of in this small volume. On examining the book, however, it will be found that the author has wisely confined his attention to the electric transmission of energy for the purpose of its being transformed at a distant place into mechanical energy for driving machinery. Indeed, it may be said that much more than half the book is devoted to the subject of the dynamo-machine, and that much less than half of it is devoted to the subject of the electric transmission of energy. Before electric energy can be transmitted it is necessary to produce it. It is rather difficult to imagine a store of electric energy existing anywhere and ready for transmission; and hence its production, transmission, and transformation into some other form of energy are circumstances which are exactly coincident with one another: as its transmission therefore implicitly involves its production and transformation, Mr. Kapp is perfectly justified in devoting as much of his book as he pleases to a description of the dynamo-machine.

Few people are better qualified to speak from experience of the most recent practice in the manufacture of dynamo-machines than the author of this book, and his paper entitled "Modern Continuous-Current Dynamo-Electric Machines and their Engines," read on November 24, 1885, before the Institution of Civil Engineers, and the discussion upon it, are to be regarded as exceedingly valuable helps to the electrical engineer. This book will be valuable to students who do not possess a copy of Mr. Kapp's original paper. It contains additional matter, much of it good; but to some of it we would offer a mild objection. For example, some distinction might have been made between the magnetic theories of Weber and Prof. Hughes. Mr. Kapp has certainly a good working knowledge of the theory of the dynamo-machine, and he leads up to the theory in a very ingenious way, but we are afraid that students will benefit more by reading an elementary treatise on electricity and magnetism, the writer of which may have had less originality than Mr. Kapp, than by taking their elementary notions from this book. Thus, for example, the following statement may have a perfectly orthodox meaning to Mr. Kapp:—"We can either assume that the lines are of different strength, and that the mechanical force with which a given free magnet pole is urged along any one particular line, is dependent on the strength of that line, which may be different from that of any other line belonging to the same field" (p. 18); but it will give great trouble to a student who knows that the resultant force is not the same at all points in a line of force, and who will find it inconsistent with the statements which Mr. Kapp has himself to make later on.

Again, we are disposed to think that it would be graceful in Mr. Kapp, and other makers of dynamo-machines at the present time, to give a little more credit to Gramme, and to refrain from dwelling so much on the great advances which have been made in recent years in the construction of dynamo-machines. When we compare modern machines with the Gramme machine of ten years ago, we see improvements on the original machine certainly, but they are very small. They consist mainly in ways of winding the conductor on the armature, so that it shall not readily slip or heat. How little of an essential kind has been introduced in the field-magnet arrangement may be gathered from the sheet of diagrams given at p. 102 of this book. In fact, a modern dynamo-machine may be said to be a Gramme or Siemens machine, the field-magnet circuit of which has been modified in a fanciful manner. Happily such modification in shape, however fanciful, does not seem to have impaired very much the efficiency of the arrangement, whereas it has enabled makers to greatly alter the outside appearances of machines, so that good Gramme and Siemens dynamo-machines are no longer called by these names, but by the names of the makers who have given them such various outside appearances. Large modern machines are superior to ancient small machines in efficiency and in the "output" per pound weight: firstly, because they are larger—and this is the main cause of their superiority; secondly, because the mechanical engineers to whom the details in construction have always been intrusted are now, some of them, slightly acquainted with the laws of electricity and magnetism; and, thirdly, because the manufacture of numerous machines has enabled costly manufacturing tools to be introduced, and these tools enable a method of construction to be employed which would in the past have been prohibited by the expense.

Again, we object somewhat to Mr. Kapp's use of the terms "theoretical" and "practical." For example, in discussing the efficiency of the electromotor when doing various amounts of work, at p. 129, he says that a certain statement which he has made is theoretically quite accurate, but from a practical point of view it requires some modification, and he proceeds to show that the want of accuracy was due to the fact that all considerations of magnetic and material friction had been neglected. We should have said in such a case that the statement was theoretically quite inaccurate. We consider that much mischief is occasionally done by what is usually called the comparison of theory and practice. If the mathematical results derived from some hypothesis which is evidently wrong be called a theory, we must of course have disagreement between theory and practice, and it is greatly in consequence of this that the majority of practical engineers have acquired a contempt for theory and for the reading of books which deal with the theoretical principles underlying their professional work. If the results of speculation on absurd hypotheses must be compared with facts, the terms to be used are "hypothetical" and "practical."

This is one of three advertised books of "The Specialists' Series" which deal with electric engineering. Another of the three is devoted to the subject of magneto- and dynamo-electric machines, and the third is on electric lighting. We think it probable that in the greater part of Mr. Kapp's book he is going over ground which belongs almost altogether to the author of one of the other books of the series. As Mr. Kapp treats his subjects well, however, we cannot much object to this ; but what we do object to is, that while taking up the subjects of the other authors, he has not given us his own subject. In sixty-three pages, or about one-fifth of the book, an instructive account is given of the various attempts which have been made to drive carriages on railways, telpher lines, ploughs, cranes, fans, and pumps, and we understand from Mr. Kapp's introduction that it is to this sort of transmission of energy that his book is devoted.

Now it is not merely sufficient for the author to give an account of what has already been done in this way ; the reader expects a correct theoretical treatment of the whole subject, the cost of conductors, the fall of potential along the conductor, and the efficiency of transmission. These questions are sufficiently well taken up for a treatise on electric lighting, but for a book on the electric driving of machines at a distance the subject can hardly be said to be touched upon. Thus, for example, the development of Sir William Thomson's law as applied in electric light installations, and published by Prof. Forbes in his lectures at the Society of Arts, is carefully given. Now small alteration of potential difference at an incandescent lamp may produce disastrous effects on the lamp, may destroy it, or may cause sudden darkness, and this is the most important consideration in arranging conductors for lighting purposes ; whereas, in the electric driving of trains or machinery, small alterations of potential difference are of no importance whatsoever. In consequence of this, in driving machinery electrically there may be a very considerable fall of potential along the conductor from the dynamo to the motor, and hence motors may be worked directly at distances which it would be absurd to contemplate in working an incandescent lamp. In fact the question of cost of conductors must be treated from quite a different point of view in the two cases, and it seems to us that Mr. Kapp has taken up the point of view which is most remote from his subject.

We think Mr. Kapp's book a very valuable addition to electrical engineering literature. It will be widely read, and it deserves the popularity which it will receive. Had we not thought it to be so excellent in many ways we should not have criticised it so narrowly, and, in spite of our warning to the student, we are very glad to meet with originality in leading up to the theory of the dynamo-machine. We are glad to see that the author has slightly amplified his account of the method, now in general use, of calculating the probable electromotive force of a dynamo-machine, which he published in his paper. The method is known to be practically correct, although it is based on a magnetic hypothesis of which there is no recognition in any book on physics—the hypothesis of magnetic resistance. We could have wished that Mr. Kapp had dwelt more upon this hypothesis, as we know of no actual results of experiment having yet been published which give it a general verification.

In reading over this criticism we feel that our objections to the book have all been brought very prominently forward. It would be very easy to point out here much that is good in the book, but perhaps our readers would then find this article long and tedious. Any reader of the book will find original and interesting views in every chapter ; it is not every reader who would for himself have noticed the faults which we have here gathered together. We have achieved the difficult task of finding fault with an excellent book.

JOHN PERRY

OUR BOOK SHELF

The Aryan Maori. By Edward Tregear. (Wellington, N.Z. : George Didsbury, 1885.)

THIS little book contains a theory that the ancestors of the New Zealanders belonged to the Aryan race, and were a pastoral people. To signify this, the cover is adorned with a golden picture, seemingly representing a Maori warrior in native guise, accompanied by a sturdy little Highland bull. Now, it being notorious that the New Zealanders, when discovered, had no cattle nor remains of them in their country, the reader's curiosity is aroused to see how Mr. Edward Tregear supports this unlikely thesis. His method proves to be a philological paradox which we have never met with before. For example, it is argued (p. 31) that the Maoris once knew the bull by a word like the latin *taurus*, a bull. How so, one asks, when they no more had the word in their vocabulary than the beast on their land? The answer is, that in the absence of the word *taurus* itself the author relies on a dozen or so of other Maori words which he alleges to refer to it. The following are a few of them :—*Tara*, had courage ; *tararau*, made a loud noise ; *tararua*, had two points or peaks ; *tareha*, was red ; *tarehu*, caught one unawares ; *tarore*, had a noose put on him ; *taruke*, lay dead in numbers (if it was characteristic of the bulls to lie dead in numbers, how multitudinous the cows and calves must have been in the Aryan-Maori herds !). The poverty of the Maori language in consonants makes it easy to the author to play this fanciful game with his dictionary to his own full satisfaction. He takes a real interest in studying the Maoris, and though he has gone astray this time, he may, if a young man, do something more worth doing in the collection of native customs, legends, games, and the like which the older natives still remember.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.*]

Tidal Friction and the Evolution of a Satellite

IN NATURE, vol. xxxiii. p. 367, is an article by Mr. G. H. Darwin, defending his theory of tidal evolution, and dealing with what I have written respecting that theory. Space will here prevent my replying at length to the above ; but as the author of it seems to think that my inquiry has been confined too much to the mode of origin of the moon, I have pushed it out in other directions, when important results have been obtained. I purpose here chiefly devoting my space to these, which can be put in a comparatively short and simple form.

But before entering on the new ground I think a few words of explanation will be necessary. Mr. Darwin takes exception to a proposition of mine in that it holds his theory to be dependent upon the genesis of the moon at the present surface of the earth. I was led to this conclusion chiefly from the apparent stress laid on the condition by the writer on that subject in Thomson and Tait's "Natural Philosophy," but as the author now states that his theory is not so founded, I think it ought to be allowed that it is not. But I think the argument can be put in another way; for if the moon be allowed to have separated at a period over four hours, the theory would be at variance with the calculations of its author (for he fixes the period at between two and four hours). A flock of meteorites is proposed as a form in which the moon might have receded from the earth. Nothing can be gained by this, for the flock of meteorites cannot come nearly so close to the earth as the moon in a single mass, without the constituent members being separated and each compelled to describe an independent orbit with its own period. In other words, the tidal force would separate the flock of meteorites at a greater distance than it would the single body. And at a greater distance it is not necessary, as the moon in her conglomerate form could not be objected to.

Also, he quotes and questions a passage, which is to the effect that two heavenly bodies cannot revolve about their centre of inertia with their surfaces nearly in contact, unless one is smaller than, and denser than, the other by a certain amount. The case was intended for where the two bodies move as parts of a rigid body, *i.e.* each keeps the same face towards the other; but I omitted to insert this condition in giving the rule.

Coming now to the results of my second investigation. In his last reply, as well as in several other places, Mr. Darwin advances the Martian system as affording a striking confirmation of the influence of tidal friction. The view is that the extreme minuteness of the inner satellite has preserved it as a standing memorial of the primitive time of rotation of Mars round his axis (see the *Observatory*, July, 1879).

Now I think it must have been taken for granted that the smallness of the satellite would allow the above state of things to come about, for an estimate of the comparative effects produced on Mars by solar and by satellite tidal friction, and the reaction on the satellite shows that, according to the estimated dimensions of the latter body, its period must be considerably more disturbed than that of Mars. Prof. Newcomb estimates the diameter of the inner satellite at from 10 to 40 miles. If we take the lower estimate and suppose the body to be only as dense as the sun, then its mass will be 86000^3 times smaller than the sun's. But the distance of the satellite—6000 miles—is 23333 times less than the sun's distance, and this number must be cubed to get the effect on the tidal force through greater proximity. After making the proper allowances, as above, it will be found that the satellite has a tidal force fifty times less than that of the sun. If the tidal retardation or acceleration, as the case may be, varies as the square of the tidal force, as Mr. Darwin allows, then 1/2500 of the planet's retardation must be counteracted by the satellite tides, which go round in the reverse direction to the solar tide. Here the reaction on the satellite must be considerable, for an approximate calculation will show that the orbital momentum of that body is only about 1/2,800,000 of the planet's rotational momentum. It will not be necessary to work out the calculation. Suffice it to say that the density and dimensions of the planet are taken from Newcomb's tables, and that the distribution of density is supposed to be like that of the earth, giving a rotational momentum equal to that of homogeneous density multiplied by 0·83.

If solar tides lengthen the Martian day by one minute, then the rotational momentum will have been reduced by about 1/1400 of the whole, and the satellite must have produced an effect in the opposite direction 2500 times as small, so that the actual effect of the satellite is to increase the rotational momentum by 1/3,500,000. And since the reaction on the satellite will be equal and in the opposite direction, more than half its momentum (which is 1/2,800,000 of the planet's) will be lost, which will reduce its distance to the surface of the planet. Hence we are led to the startling conclusion that before solar tidal friction can alter the rotation-period of Mars by one minute, the inner satellite must fall into the planet. I have not taken into the calculation the circumstance that the satellite tide goes round quicker than the solar one, nor that, as the satellite approached the planet, its tides would increase, the purpose here being only to give an account of the relative changes that should take place at about the present configuration. Further, it would seem that solar tides could not have reduced the period of Mars much, even if it be supposed that the inner satellite was first at any greater distance, for then it must either have gone out and attained a longer period than Mars, or it must have fallen into the central body long ere this. There seems no escape from these conclusions, unless the little body gives out an extraordinary amount of light for its size (for its probable size is judged by its brightness), but this seems so improbable, that it would be unreasonable to suppose so. As for the density, the inferior limit must be not less than half that allowed, otherwise the tidal force of the planet would break the body up.

Now a few words may be said on the future history of the moon. Before, I have said that the tracing back of the moon has apparently been carried too far in one direction; and now I think that the tracing forward, supposing tidal friction to have free play in the future, has been carried too far in the other direction. According to Thomson and Tait ("Elements of Natural Philosophy"), the moon's distance should increase to 347,100 miles by the time the earth's rotation relatively to the moon is stopped, when the two bodies should revolve in about 48·3 days. Now it would take all the rotative momentum that the earth would lose during the change to send the moon to the above distance; or, in other words, if there were no solar tides or other causes to prevent all the rotational momentum lost by the earth going to increase the moon's orbital momentum, the moon's distance would not be increased to beyond the above. But it is clear that a considerable portion of the rotative energy would be lost in solar tidal friction, which would have no part in increasing the moon's distance from the earth. For the moon to recede to the distance named, the earth must not only have its present moment of momentum, but also as much as solar tides would extract during the interval. At the present time the retardation through solar tides is not a small fraction of the whole, and it should increase till, at the other end of the journey, it will be more than half the whole retardation, for then the solar will be greater than the lunar tide.

I believe that Messrs. Darwin and Ball, who wrote a year or two before the date of Thomson and Tait's work, give the distance to which the moon will recede as even greater than the above, and say her period of revolution will be about fifty days. Certain remarks made by Mr. Darwin in the larger work of Thomson and Tait leave some doubt as to whether a correction has recently been made in the moment of momentum of the earth's rotation, but even if the earth be supposed homogeneous, the rotational momentum would not be sufficient to send the moon to the above distance, when allowance is made for solar tidal retardation. Hence it seems that no allowance has been made for the effects of this agency, and that when such allowance is made, the moon's destination must fall far short of the estimates given. If the distance (347,100 miles) be reduced to about 320,000 miles, I think it would be nearer the mark.

Mr. Darwin says that the eccentricity of the lunar orbit, the obliquity of the ecliptic, and other elements would be coordinated together by supposing that the moon first had a separate existence at no great distance from the present surface of the earth, and with small differential motion with respect thereto. I will only say that the case is so complicated, and the data so unreliable, that the results of the calculations involved seem to be little better than guess-work.

As for the distribution of satellites in the solar system, I think the majority of diverse theories would hold that they should be more numerous far from the sun, for the simple reason that solar disturbance would be less there. JAMES NOLAN

Dergholm, Victoria, May 25

MR. NOLAN is correct in supposing that I made no numerical calculation with regard to the inner satellites of Mars. I accept the calculation which he gives, and admit that the present period of revolution of the satellite cannot be regarded, as I supposed, as a memorial of the primitive period of rotation of the planet.

I see, however, no reason, as yet, to recede from the following statement (*Phil. Trans.*, Part II. 1880, p. 883), which embodies the essence of the argument, without the erroneous phrase:—

"It is here (in the case of Mars) alone in the whole system that we find a satellite moving orbitally faster than the planet rotates. This will also be the ultimate fate of our moon, because, after the moon's orbital motion has been reduced to identity with that of the earth's rotation, solar tidal friction will further reduce the earth's angular velocity, the tidal reaction on the moon will be reversed, and the moon's orbital velocity will increase, and her distance from the earth will diminish. But since the moon's mass is very large, the moon must recede to an enormous distance from the earth, before this reversal will take place. Now the satellites of Mars are very small, and therefore they need only to recede a short distance from the planet before the reversal of tidal friction."

No one can have any datum for saying that the Martian satellite must have fallen into the planet "long ere this," but Mr. Nolan shows that the satellite is now near the end of its history.

I do not think that Sir William Thomson made any allowance for solar tidal friction in estimating the ultimate distance of the moon. Both he and I only cared to obtain the result in round numbers.

I should be very much obliged to Mr. Nolan if he would give a reference to the proof of the theorem, that two heavenly bodies cannot revolve about their centre of inertia, as parts of a rigid body with their surfaces nearly in contact, unless one is smaller and denser than the other by a certain amount.

July 15 G. H. DARWIN

Peripatus in Demerara

CONSIDERING the great antiquity and importance of *Peripatus* it seems desirable to make a public notification of the fact that I have found a species, apparently *Peripatus Edwardsi*, in the Demerara division of British Guiana. Four specimens were obtained by me, but three of them, owing to some unknown cause, became considerably damaged and practically useless. The fourth specimen, which was found by me nearly a month ago, is still alive and evidently in good health. It is, when in progression, about 3½ inches in length, but it often elongates itself considerably more and at other times becomes nearly coiled into a thick lump. It possesses thirty-one pairs of feet, the last three of which it rarely puts to the ground except when it goes backwards for short distances. Several other pairs at intervals along the body are carried off the ground in the same manner. It seems distinctly restless under the influence of light, appearing comfortable only when it retreats into some moist and darkened corner. When handled, it frequently discharges its viscid secretion, but as frequently neglects to do it when handled for the first time after a long interval, but more especially when touched or taken up for three or four times in rapid succession. It has been kept in an old sardine tin with small pieces of decayed wood, which were taken from the stump in which it was found, and the wood is kept in a moist condition. The locality from which it was obtained was the Hoorubea Creek, about twenty miles from Georgetown, on the east coast of the Demerara River, close to the meeting-point of an extensive forest and a water savannah. The four specimens were obtained in the same locality; and, though I have sought for them continually in other places, up to the present I have been unable to find others. From the long period of time during which this specimen has survived in confinement, I think there will be no difficulty, when I have obtained a large number of specimens, in sending them alive to England to Prof. Moseley and others. Unfortunately I have no possible access here to any literature on the group. I do not think it is generally known, but Mr. Im Thurn has once previously found specimens of Peripatus in the Essequebo division of British Guiana. His specimens were, however, very small ones.

British Guiana Museum JOHN J. QUELCH

Upper Wind-Currents over the Bay of Bengal in March, and Malaysia in April and May

IN my last letter to NATURE, vol. xxxiii. p. 460, on the subject of upper winds, I described the circulation of the Indian Ocean from the equator, where the north-west wind changes into the north-east monsoon, as far north as Ceylon, in the month of February. From there, about the beginning of March, I took a section of the weather, as nearly straight as practicable, from Colombo, through Calcutta, and 400 miles due north to Darjeeling.

The general weather system at that season is very simple. A belt of high pressure lies across the Bay of Bengal, from about Madras, to the southern limits of Burmah. The north-east monsoon blows to the south of this, towards the low pressure below the equator; the belt, of course, covers a calm area; while to the north a south-west wind blows towards a low pressure somewhere beyond the Himalayas.

The upper currents over the north-east monsoon always blew from some more easterly point than the surface-wind; the cloudless sky over Madras prevented any observations; north of this the higher clouds always came from some point more northerly than the south-west wind below. The lofty range of the Himalayas seemed to make no difference; at Sendukphu I succeeded in getting a photograph of a cumulo-form cloud trailing from the summit of Kanching Junga (29,000 feet) well from the west-north-west, while a south-west wind was driving up mist from the plains. The existence of cumulus at so high a level has, I think, been denied by some meteorologists.

All these observations are in complete accordance with the normal circulation of the northern hemisphere; but the character of south-west monsoons deserves notice. The term south-west monsoon is unfortunately used for two different stages of the same weather sequence, and much confusion comes thereby. Maury and others think only of the direction of the wind; common parlance all over the East talks of the monsoon as of a rainy season which sets in suddenly, long after south-west winds have been blowing for weeks or months previously.

The facts of the case are these:—As early as January a light south-west wind commences in the north of the Bay of Bengal, first only as a sea breeze; later, when we encountered it, as a light continuous wind. Nothing can be more lovely than the weather then; bright blue sky, scarcely a light cloud, with a warm gentle wind; the monsoon, unlike March, begins like a lamb and goes out like a lion. As the season goes on an area of low pressure, which has been gradually forming over Northern Bengal, becomes more pronounced, and the south-west wind gradually works further and further to the southwards below Ceylon. Then, sometimes in June, a sudden total change comes over the weather, while the only alteration the isobars show is a slight motion of the lowest pressure towards the North-west Provinces of India. A sudden burst of rain and thunder breaks over Ceylon, and then the bad weather works slowly northwards. This is the commencement of the south-west monsoon in common talk. Everyone will tell you how many days it takes to work up to Bombay on one side and to Calcutta, by way of Burmah and Assam, on the other. Madras escapes for the present, only to be deluged in November by the north-east monsoon. So we get the curious sequence that the wind works downwards, the rain upwards; and also the fact that the greatest and most sudden change in the year is associated with no striking change in the distribution of pressure. The Indian meteorologists are of opinion that this sudden change in the character of the same wind is due to a sudden irruption of air, highly charged with vapour from the neighbourhood of the equatorial doldrums, but that the south-east trade is not linked with the south-west monsoon in a continuous current, except occasionally and temporarily. Would it not be of the highest interest and importance to discover whether this sudden change of weather is associated with any change in the relation of the upper and lower winds? In my letter to NATURE (vol. xxxiii. p. 460) I showed that over the south-west monsoon of the Gulf of Guinea the upper currents were those of the southern hemisphere, and that the south-east trade there seemed to grow gradually into a south-west wind as it crossed the line. If in Ceylon and India the higher clouds continue to come, as we found them, from west or north-west after the burst of the south-west monsoon, there must be a doldrum between it and the south-east trade; but if the upper currents turn towards south or south-east after the burst, then undoubtedly the south-east trade has invaded the northern hemisphere. The latter is of course the old theory of the monsoon; and perhaps another test may be applied to the solution of these alternatives. If the south-east trade blows into a doldrum, there must be a belt of high pressure between Ceylon and the equator to give gradients for south-west winds. Has this ever been found? I do not think that calm alone is sufficient to be called a "doldrum." During the north-west monsoon, which is unquestionably the north-east monsoon drawn across the line, the direction of the wind changes gradually, but the velocity is often less just on the equator than on either side. I made some special inquiries on this point.

In the Philippines, China, and Japan the upper winds over the south-west monsoon follow the normal course of the northern hemisphere; but there is no burst of the monsoon in those countries.

Some meteorologists have asserted that the south-west monsoon may be considered a stationary cyclone. This might be so if we define a cyclone simply as an irregularly circular area of low pressure round and into which the wind blows spirally. But when we look at the kind of rain and varieties of cloud which give distinctive character to various parts of a cyclone, our own observations and the information we have received from others entirely discountenance this idea.

In Malaysia, between Singapore and Borneo, in the early days of April the surface-winds were all from about north-east, and the clouds at various levels always from more south of east. In North Borneo, later in the month, the south-west land breeze of the morning always went round by south-east to north-east in the afternoon and evening, while the higher clouds came always from about north-east.

In Sooloo and the Philippines during the month of May the surface winds were much complicated by land and sea breezes, but the sequence of upper currents was always that proper to the hemisphere.

So far for ordinary weather. I was not fortunate enough to meet with a typhoon, but the reports of the observatories at Manilla, Hong Kong, and Tokio are all agreed that the relation of upper and lower currents is the same in a typhoon in the China Seas as in a European cyclone.

Yokohama, June 12 RALPH ABERCROMBY

Mock Sun

I INCLOSE sketch of the first mock sun I have been fortunate enough to see at Cranbrook, Kent, on July 20, 5 to $5\frac{1}{2}$ p.m.

About 10m. before noticing this fine phenomenon we had noticed a fragment of it, not knowing what was to follow; and we were struck by the extraordinary position of the bow with reference to the sun, viz. about 45° from it, and at an unaccountable angle to the horizon. The latter picture I can only draw by memory. The upper drawing is from one made on the spot in presence of two intelligent adult witnesses, who were consulted on each point which I proceed to notice.

(1) The rainbow near the zenith was of the breadth and brilliancy of an ordinary rainbow (the same was the case with the fragment seen ten minutes earlier, which was lost when the rest came out). The fact of the arc seen near the zenith belonging to two circles, one small and one large, touching each other, was sufficiently certain to my eye, confirmed by another educated eye, but not admitted by the third less educated one. I draw it as I apprehended it. The colours were unusually vivid against a thin veil of fleecy clouds.

(2) The halo-circle round the sun, and the arched eyebrows, so to call them, were about half the breadth of the rainbow, and washy in colour. The shapes drawn are quite faithful, and were so sharp as to leave no room whatever for doubt or imagination.

(3) The interior area of the circle was darker than the ouside.

(4) The position of the mock sun was not diametrical. The sun, seen through a handkerchief whose edge was stretched through the two mocks, was about two-thirds of its own breadth below the edge, clear.

(5) The white rays (about half the breadth of the mock lights) were seldom seen both at the same time, but were quite decided outside the circle and traceable within it, but nowhere nearly so bright as the mock lights.

(6) The mock lights were short fragments of arcs of rainbows, more vividly coloured than the halo-circle outside of which they stood clear of it, but not so broad and not quite so vivid as the great rainbow arc.

These fragments were *not* tangential. Short as they were, their own axis was clearly determined by all three witnesses to be inclined towards the radial ray, and more inclined to the arc of the halo. But I have unconsciously given a curved shape to the short fragment. It was too short to show a curve. There was no pretence of a disk, as if really a mock sun. It was only a very vivid fragment of a rainbow. A third fainter one was at the top of the halo.

The sky was much covered with thin cirrus; a fine sunny evening; air peculiarly clear for distant views.

Collingwood, July 22 W. J. HERSCHEL

P.S.—Radius of halo-circle, measured as best I could, $22\frac{1}{2}^\circ \pm 2\frac{1}{2}^\circ$. Radius, continued to the rainbow, 45° with proportionate error. The arc of the halo-circle was generally absent next to the mock lights, but could sometimes be traced.

"The Duration of Germ-Life in Water"

IN a letter bearing this title in your last issue (p. 265) Mr. Downes refers to the recent publication by Messrs. Crookes, Odling, and Tidy, of some experiments which they have made on the vitality of the *Bacillus anthracis* in water, with regard to which I should like to call attention to the fact that this subject has during the past three years been investigated by various experimenters, including Koch, Cornil, and Babes, Nicati and Rietsch. Within the past two months no less than three papers have been published on this subject, two of them in Germany by Dr. Wolfhügel and Meade Bolton respectively, whilst the third, by myself, "On the Multiplication of Micro-organisms," was communicated to the Royal Society at the meeting in June last. In this paper I have recorded a number of experiments made both with the mixtures of organisms found in various natural waters, as well as with three well-characterised forms which are associated with disease, viz. Koch's "Comma" spirillum of Asiatic cholera, Finkler-Prior's "Comma" spirillum of European cholera, and the Bacillus pyocyaneus, which produces the greenish-blue colouring matter frequently present in abscesses. The methods of research which have been independently selected both by Wolfhügel, Meade Bolton, and myself, are identical, and consist in the examination, by gelatine plate-cultivation, of waters purposely impregnated with the organisms in question. This method is obviously the one which most recommends itself for the purpose, as it not only enables one to ascertain the presence or absence of the organisms, but also to quantitatively follow their multiplication or reduction. I may mention that these three organisms present great differences in their behaviour under similar circumstances; thus the *Bacillus pyocyaneus* is possessed of far greater vitality in water than either of the other two, its presence being demonstrable even in distilled water after fifty-three days, in numbers exceeding manyfold those originally introduced. Koch's "Comma" spirillum, on the other hand, was in the purest forms of potable water no longer demonstrable after the ninth day, whilst in London sewage it was found in largely multiplied numbers after twenty-nine days; whilst Finkler's spirillum could in no case be detected after the first day, and frequently not even on the day of inoculation. A curious phenomenon, which my experiments, as well as those of Wolfhügel and Meade Bolton have brought to light, is that when organisms of this kind, which are not the natural inhabitants of water, are introduced into this medium, a large proportion of them are frequently at first destroyed, a greater or less multiplication in their numbers often subsequently taking place.

The *Bacillus anthracis*, as is well known to bacteriologists, appears in two very distinct forms, the *bacillus*-form and the *spore*-form, and these present very great differences in their powers of endurance, the former being destroyed with comparative ease, whilst the spores are remarkable for their vitality. Mr. Crookes and his colleagues have apparently experimented with the bacillus-form of anthrax only, which they state is rapidly destroyed when introduced into London water, but Dr. Meade Bolton, who has dealt with anthrax in both its forms, has shown that the spores of anthrax retain their vitality even in distilled water for upwards of ninety days, and that it is only the bacilli which rapidly perish in some kinds of potable water. In polluted well-water Meade Bolton has also shown that even the bacilli are persistent for upwards of ninety days, and the spores for nearly a year, whilst Wolfhügel has found that in polluted river-water (the River Panke, in Berlin), even when diluted tenfold with distilled water, the anthrax bacilli undergo extensive multiplication. PERCY F. FRANKLAND

Normal School of Science,
South Kensington Museum, S.W., July 26

Animal Intelligence

IN NATURE for July 22, on p. 265, Mr. Frederick Lewis calls attention to a nest-building wasp who closed up her nest without filling it first with grubs or laying an egg. There is nothing uncommon in this neglect on the part of the wasp, as any one who has at all studied their habits in the tropics will know, such perfectly empty nests being frequently met with. I have often thought the empty nest might have something to do with the fact that the wasp may not have been prepared to deposit her egg; but then, if that were the case, we should occasionally find nests with the remains of the caterpillars or spiders collected. When a wasp has once chosen a site for building, it is very difficult to drive her away.

63, St. George Street, Leeds HY. LING ROTH

The Microscope as a Refractor

I AM rather surprised, after the judicious remarks of Dr. Gladstone on this subject in NATURE of July 1 (p. 192), to find Mr. Gordon Thompson still maintaining his opinion to have introduced anything not yet known or tried with the microscope adapted to this purpose. If he had had time to go over the papers of Royston Pigott (*Proceedings* of the Royal Society, 1876), of Mr. Sorby (*Mineralogical Magazine*, 1878), and of myself (*Proceedings* of the Royal Society, 1884), he could have convinced himself that all what he proposes has been already elaborated and applied. He could also have learnt why the method with the microscope is limited in its exactitude to the third decimal, as the mathematical expression which it involves is deduced from not very strict principles, this being as well the case with the formula for the hollow prism.

The Hague, July 21 L. BLEEKRODE

HERRMANN ABICH

AS briefly reported in NATURE last week this venerable geologist died at Vienna on July 1. As far back as the year 1831 he began his scientific career by the publication of an important memoir, in which by novel methods of chemical analysis he determined the composition of various minerals of the Spinel family, and showed how alike by chemical composition and crystalline form they could all be ranged in one group. This early paper gave evidence of the carefulness of observation which distinguished him through life. It was followed by other chemical and mineralogical essays, especially in the department of volcanic products. Gradually he was led to devote special attention to the phenomena of volcanic action, and in the course of his investigations to visit most of the volcanic districts of Europe. His folio atlas of views illustrative of Vesuvius and Etna (1837), and his "Vulkanische Bildungen" (1841), are among the best known of his writings. He had great facility as a sketcher, and some of his drawings of volcanic craters have done duty for nearly half a century in text-books in many languages. The east of Europe presented a wide and almost unknown field for his exploration. As far back as 1840 he published notices of his wanderings in the Caucasus. He ascended to the summit of Mount Ararat, and devoted most of the remainder of his life to the investigation of the vast region of the Caucasus and south-eastern Europe. Many papers published from time to time in the scientific journals record his unwearied industry. But perhaps the most striking and durable monument of his scientific achievements is his great work, "Geologische Forschungen in den Kaukasischen Ländern," the publication of which he was superintending at the time of his death. This magnificent monograph, of which only the first part has been published, brings before the reader in a series of maps, sketches, large panoramic views, and detailed descriptions a picture of the external aspect and geological structure of the Caucasian region and impresses him with a profound admiration for the author's geological prowess. Abich had during the last few years settled in Vienna, availing himself of the typographic facilities to be found in the Austrian capital. He has been a notable instance of the longevity attained by many active field-geologists, for he almost reached the age of three score and ten years, retaining to the end his enthusiasm and industry. It is to be hoped that the second part of his monumental work, which is to treat of the eastern half of the Armenian Highlands, has been left in such a state as to admit of publication.

CAPILLARY ATTRACTION[1]

II.

NOW in this second way we have, in performing the folding motion, allowed the water surface to become less by 60 square centimetres. It is easily seen that, provided the radius of curvature in every part of the surface exceeds one or two hundred times the extent of distance to which the molecular attraction is sensible, or, as we may say practically, provided the radius of curvature is everwhere greater than 5000 micro-millimetres (that is, the two-hundredth of a millimetre), we should have obtained this amount of work with the same diminution of water-surface, however performed. Hence our result is that we have found 4·5/60 (or 3/40) of a centimetre-gramme of work per square centimetre of diminution of surface. This is precisely the result we should have had if the water had been absolutely deprived of the attractive force between water and water, and its whole surface had been coated over with an infinitely thin contractile film possessing a uniform contractile force of 3/40 of a gramme weight, or 75 milligrammes, per lineal centimetre.

It is now convenient to keep to our ideal film, and give up thinking of what, according to our present capacity for imagining molecular action, is the more real thing—namely, the mutual attraction between the different portions of the liquid. But do not, I entreat you, fall into the paradoxical habit of thinking of the surface film as other than an ideal way of stating the resultant effect of mutual attraction between the different portions of the fluid. Look, now, at one of the pieces of water ideally rigidified, or, if you please, at the two pieces put together to make one. Remember we are at the centre of the earth. What will take place if this piece of matter resting in the air before you suddenly ceases to be rigid? Imagine it, as I have said, to be enclosed in a film everywhere tending to contract with a force equal to 3/40 of a gramme or 75 milligrammes weight per lineal centimetre. This contractile film will clearly press most where the convexity is greatest. A very elementary piece of mathematics tells us that on the rigid convex surface which you see, the amount of its pressure per square centimetre will be found by multiplying the sum[2] of the curvatures in two mutually-perpendicular normal sections

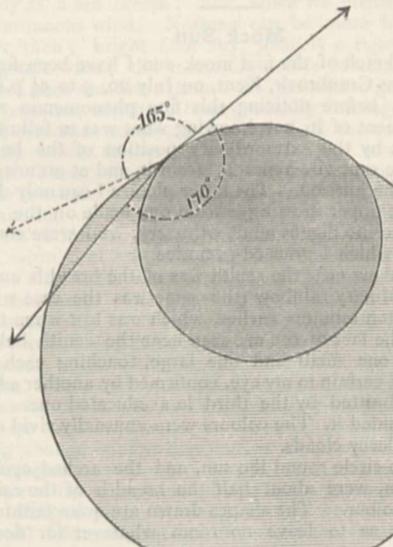

FIG. 2.

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[1] Continued from p. 272.

[2] This sum for brevity I henceforth call simply "the curvature of the surface" at any point.

by the amount of the force per lineal centimetre. In any place where the surface is concave the effect of the surface tension is to suck outwards—that is to say, in mathematical language, to exert negative pressure inwards. Now, suppose in an instant the rigidity to be annulled, and the piece of glass which you see, still undisturbed by gravity, to become water. The instantaneous effect of these unequal pressures over its surface will be to set it in motion. If it were a perfect fluid it would go on vibrating for ever with wildly-irregular vibrations, starting from so rude an initial shape as this which I hold in my hand. Water, as any other liquid, is in reality viscous, and therefore the vibrations will gradually subside, and the piece of matter will come to rest in a spherical figure, slightly warmed as the result of the work done by the forces of mutual attraction by which it was set in motion from the initial shape. The work done by these forces during the change of the body from any one shape to any other is in simple proportion to the diminution of the whole surface area; and the configuration of equilibrium, when there is no disturbance from gravity, or from any other solid or liquid body, is the figure in which the surface area is the smallest possible that can enclose the given bulk of matter.

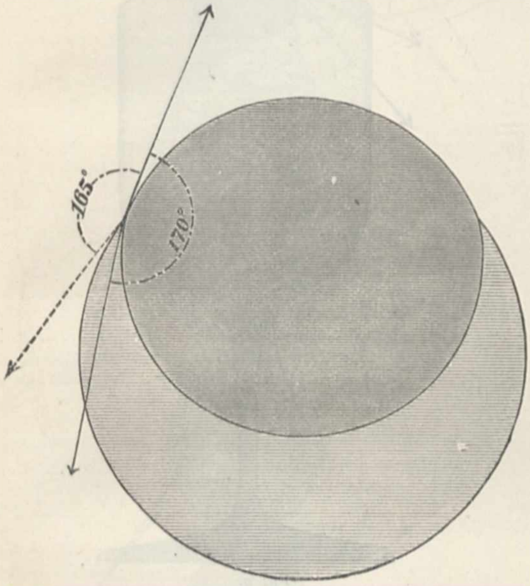

FIG. 3.

I have calculated the period of vibration of a sphere of water[1] (a dew-drop!) and find it to be $\frac{1}{4} a^{\frac{3}{2}}$, where a is the radius measured in centimetres; thus—

For a radius of	$\frac{1}{4}$	cm. the period is	$\frac{1}{32}$	second
,,	1	,, ,,	$\frac{1}{4}$	,,
,,	2·54	,, ,,	1	,,
,,	4	,, ,,	2	,,
,,	16	,, ,,	16	,,
,,	36	,, ,,	36	,,
,,	1407	,, ,,	13,200	,,

The dynamics of the subject, so far as a single liquid is concerned, is absolutely comprised in the mathematics without symbols which I have put before you. Twenty pages covered with sextuple integrals could tell us no more.

Hitherto we have only considered mutual attraction between the parts of two portions of one and the same liquid—water for instance. Consider, now, two different kinds of liquid: for instance, water and carbon disulphide (which, for brevity, I shall call sulphide). Deal with them exactly as we dealt with the two pieces of water. I need not go through the whole process again; the result is obvious. Thirty times the excess of the sum of the surface-tensions of the two liquids separately, above the tension of the interface between them, is equal to the work done in letting the two bodies come together directly over the supposed area of thirty square centimetres. *Hence the interfacial tension per unit area of the interface is equal to the excess of the sum of the surface-tensions of the two liquids separately, above the work done in letting the two bodies come together directly so as to meet in a unit area of each.* In the particular case of two similar bodies coming together into perfect contact, the interfacial tension must be zero, and therefore the work done in letting them come together over a unit area must be exactly equal to twice the surface-tension; which is the case we first considered.

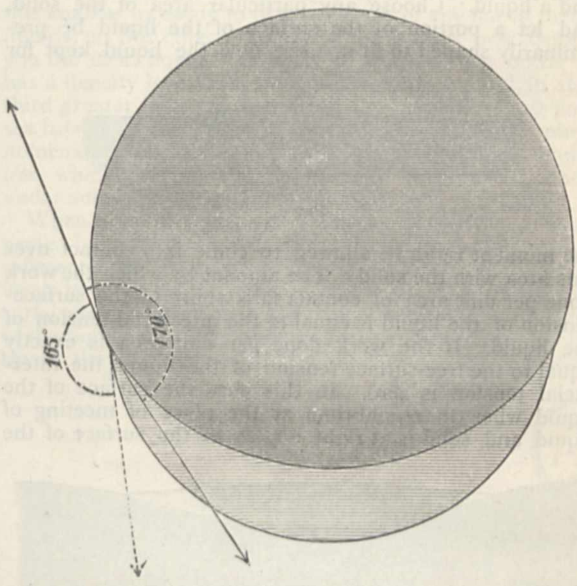

FIG. 4.

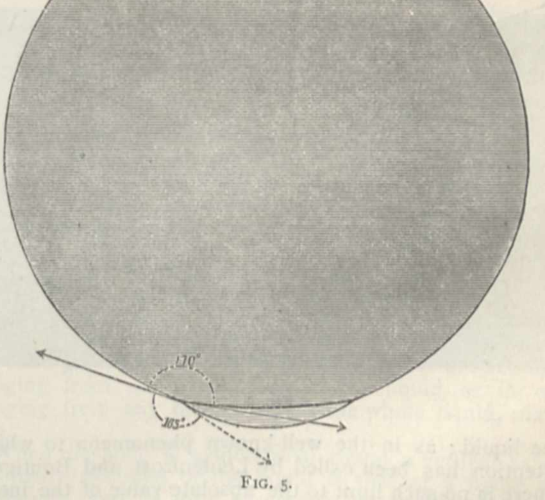

FIG. 5.

If the work done between two different liquids in letting

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[1] See paper by Lord Rayleigh in *Proc. Roy. Soc.*, No. 196, May 5, 1879.

them come together over a small area, exceeds the sum of the surface-tensions, the interfacial tension is negative. The result is an instantaneous puckering of the interface, as the commencement of diffusion and the well-known process of continued inter-diffusion follows.

Consider next the mutual attraction between a solid and a liquid. Choose any particular area of the solid, and let a portion of the surface of the liquid be preliminarily shaped to fit it. Let now the liquid, kept for the moment rigid, be allowed to come into contact over this area with the solid. The amount by which the work done per unit area of contact falls short of the surface-tension of the liquid is equal to the interfacial tension of the liquid. If the work done per unit area is exactly equal to the free-surface tension of the liquid, the interfacial tension is zero. In this case the surface of the liquid when in equilibrium at the place of meeting of liquid and solid is at right angles to the surface of the solid. The angle between the free surfaces of liquid and solid is acute or obtuse according as the interfacial tension is positive or negative; its cosine being equal to the interfacial tension divided by the free-surface tension. The greatest possible value the interfacial tension can have is clearly the free-surface tension, and it reaches this limiting value only in the, not purely static, case of a liquid resting on a solid of high thermal conductivity, kept at a temperature greatly above the boiling-point of the liquid; as in the well-known phenomena to which attention has been called by Leidenfrost and Boutigny. There is no such limit to the absolute value of the interfacial tension when negative, but its absolute value must be less than that of the free surface tension to admit of equilibrium at a line of separation between liquid and solid. If minus the interfacial tension is exactly equal to the free-surface tension, the angle between the free surfaces at the line of separation is exactly 180°. If minus the interfacial tension exceeds the free-surface tension, the liquid runs all over the solid, as, for instance, water over a glass plate which has been very perfectly cleansed. If for a moment we leave the centre of the earth, and suppose ourselves anywhere else in or on the earth, we find the liquid running up, against gravity, in a thin film over the upper part of the containing vessel, and leaving the interface at an angle of 180° between the free surface of the liquid, and the surface of the film adhering to the solid above the bounding line of the free liquid surface. This is the case of water contained in a glass vessel, or in contact with a piece of glass of any shape, provided the surface of the glass be very perfectly cleansed.

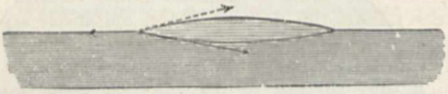

FIG. 6.

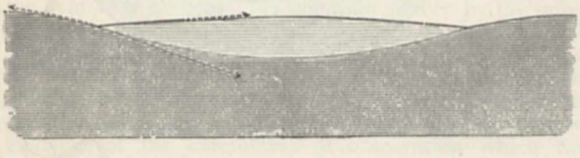

FIG. 7.

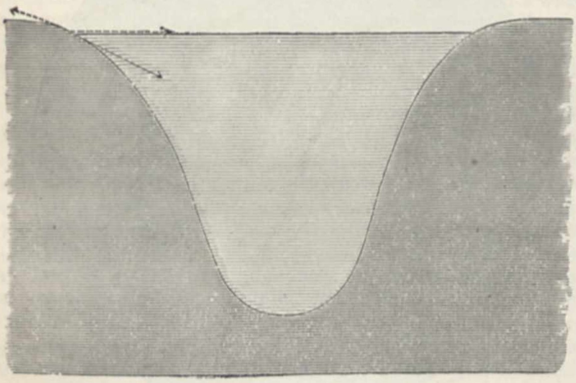

FIG. 8.

When two liquids which do not mingle, that is to say, two liquids of which the interfacial tension is positive, are placed in contact and left to themselves undisturbed by gravity (in our favourite laboratory in the centre of the earth suppose), after performing vibrations subsiding in virtue of viscosity, the compound mass will come to rest, in a configuration consisting of two intersecting segments of spherical surfaces constituting the outer boundary of the two portions of liquid, and a third segment of spherical surface through their intersection constituting the interface between the two liquids. These three spherical surfaces meet at the same angles as three balancing forces in a plane whose magnitudes are respectively the surface tensions of the outer surfaces of the two liquids and the tension of their interface. Figs. 2 to 5 illustrate these configurations in the case of bisulphide of carbon and water for several different proportions of the volumes of the two liquids. (In the figures the dark shading represents water in each case.) When the volume of each liquid is given, and the angles of meeting of the three surfaces are known, the problem of describing the three spherical surfaces is clearly determinate. It is an interesting enough geometrical problem.

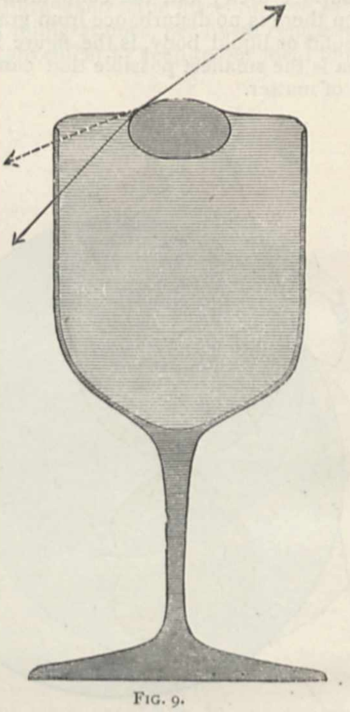

FIG. 9.

If we now for a moment leave our gravitationless laboratory, and, returning to the Theatre of the Royal Institution, bring our two masses of liquid into contact, as I now do in this glass bottle, we have the one liquid floating upon the other, and the form assumed by the floating liquid may be learned, for several different cases, from the phenomena exhibited in these bottles and glass beakers, and shown on an enlarged scale in these two diagrams (Figs. 6 to 8); which represent bisulphide of carbon floating on the surface of sulphate of zinc, and in this case (Fig. 8) the bisulphide of carbon drop is of nearly the maximum size capable of floating. Here is the bottle whose contents are represented in Fig. 8, and we shall find that a very slight vertical disturbance serves to submerge the mass of bisulphide of carbon. There now it has sunk, and we shall find when its vibrations have ceased that the bisulphide of carbon has taken the form of a large sphere supported within the sulphate of zinc. Now, remembering that we are again at the centre of the earth, and that gravity does not hinder us, suppose the glass matter of the bottle suddenly to become liquid sulphate of zinc, this mass would become a compound sphere like the one shown on this diagram (Fig. 3), and would have a radius of about 8 centimetres. If it were sulphate of zinc alone, and of this magnitude, its period of vibration would be about 5½ seconds.

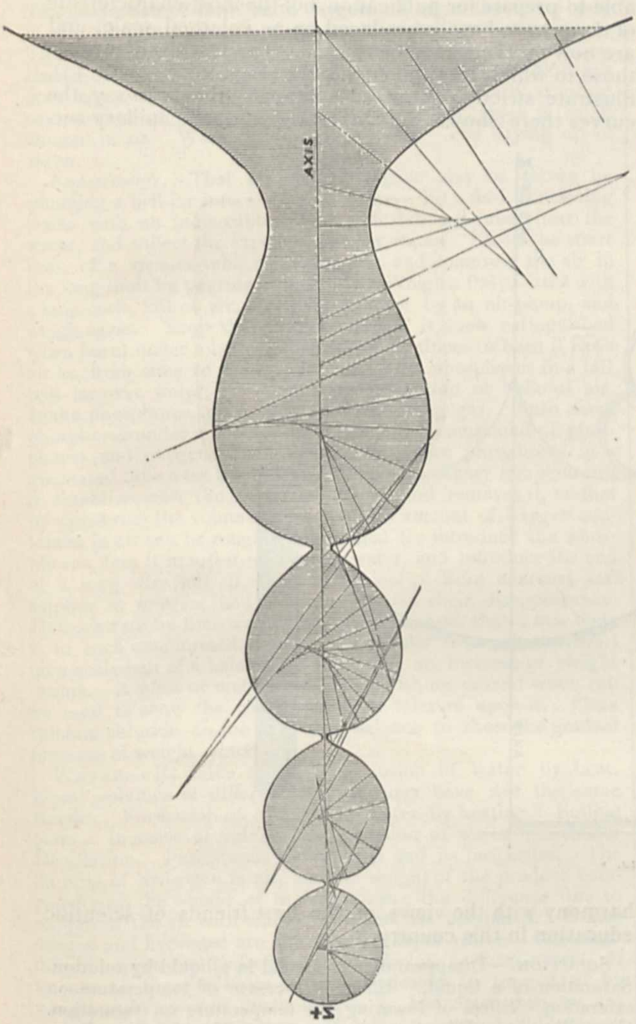

Fig. 10.

Fig. 9 shows a drop of sulphate of zinc floating on a wine-glassful of bisulphide of carbon.

In observing the phenomena of two liquids in contact, I have found it very convenient to use sulphate of zinc (which I find, by experiment, has the same free-surface tension as water) and bisulphide of carbon; as these liquids do not mix when brought together, and, for a short time at least, there is no chemical interaction between them. Also, sulphate of zinc may be made to have a density less than, or equal to, or greater than, that of the bisulphide, and the bisulphide may be coloured to a more or less deep purple tint by iodine, and this enables us easily to observe drops of any one of these liquids on the other. In the three bottles now before you the clear liquid is sulphate of zinc—in one bottle it has a density less than, in another equal to, and in the third greater than, the density of the sulphide—and you see how, by means of the coloured sulphide, all the phenomena of drops resting upon or floating within a liquid into which they do not diffuse may be observed, and, under suitable arrangements, quantitatively estimated.

When a liquid under the influence of gravity is supported by a solid, it takes a configuration in which the difference of curvature of the free surface at different levels is equal to the difference of levels divided by the surface tension reckoned in terms of weight of unit bulk of the liquid as unity; and the free surface of the liquid leaves the free surface of the solid at the angle whose cosine is, as stated above, equal to the interfacial tension divided by the free-surface tension, or at an angle of 180° in any case in which minus the interfacial tension exceeds the free-surface tension. The surface equation of equilibrium and the boundary conditions thus stated in words, suffice fully to determine the configuration when the volume of the liquid and the shape and dimensions of the solid are given. When I say determine, I do not mean unambiguously. There may of course be a multiplicity of solutions of the problem; as, for instance, when the solid presents several hollows in which, or projections hanging from which, portions of the liquid, or in or hanging from any one of which the whole liquid, may rest.

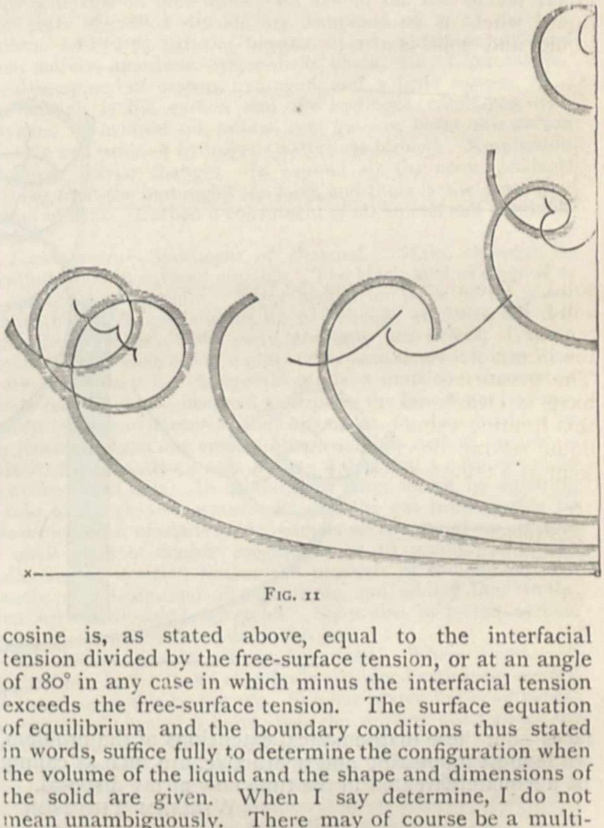

Fig. 11

When the solid is symmetrical round a vertical axis, the figure assumed by the liquid is that of a figure of revolution, and its form is determined by the equation given above in words. A general solution of this problem by the methods of the differential and integral calculus transcends the powers of mathematical analysis, but the following simple graphical method of working out what constitutes mathematically a complete solution, occurred to me a great many years ago.

Draw a line to represent the axis of the surface of revolution. This line is vertical in the realisation now to be given, and it or any line parallel to it will be called vertical in the drawing, and any line perpendicular to it will be called horizontal. The distance between any two horizontal lines in the drawing will be called *difference of levels*.

Through any point, N, of the axis draw a line, N P, cutting it at any angle. With any point, O, as centre on the line N P, describe a very small circular arc through P P′, and let N′ be the point in which the line of O P′ cuts the axis. Measure N P, N′ P′, and the difference of levels between P and P′. Denoting this last by δ, and taking a as a linear parameter, calculate the value of

$$\left(\frac{\delta}{a^2}+\frac{1}{\mathrm{OP}}+\frac{1}{\mathrm{NP}}-\frac{1}{\mathrm{N'P'}}\right)^{-1}.$$

Take this length on the compasses, and putting the pencil point at P′, place the other point at O′ on the line P′ N′, and with O′ as centre, describe a small arc, P′ P″. Continue the process according to the same rule, and the successive very small arcs so drawn will constitute a curved line, which is the generating line of the surface of revolution inclosing the liquid, according to the conditions of the special case treated.

This method of solving the capillary equation for surfaces of revolution remained unused for fifteen or twenty years, until in 1874 I placed it in the hands of Mr. John Perry (now Professor of Mechanics at the City and Guilds Institute), who was then attending the Natural Philosophy Laboratory of Glasgow University. He worked out the problem with great perseverance and ability, and the result of his labours was a series of skilfully executed drawings representing a large variety of cases of the capillary surfaces of revolution. These drawings, which are most instructive and valuable, I have not yet been able to prepare for publication, but the most characteristic of them have been reproduced on an enlarged scale, and are now on the screen before you.[1] Three of the diagrams, those to which I am now pointing (Figs. 10, 11, and 12), illustrate strictly theoretical solutions—that is to say, the curves there shown do not represent real capillary surfaces—but these mathematical extensions of the problem, while most interesting and instructive, are such as cannot be adequately treated in the time now at my disposal.

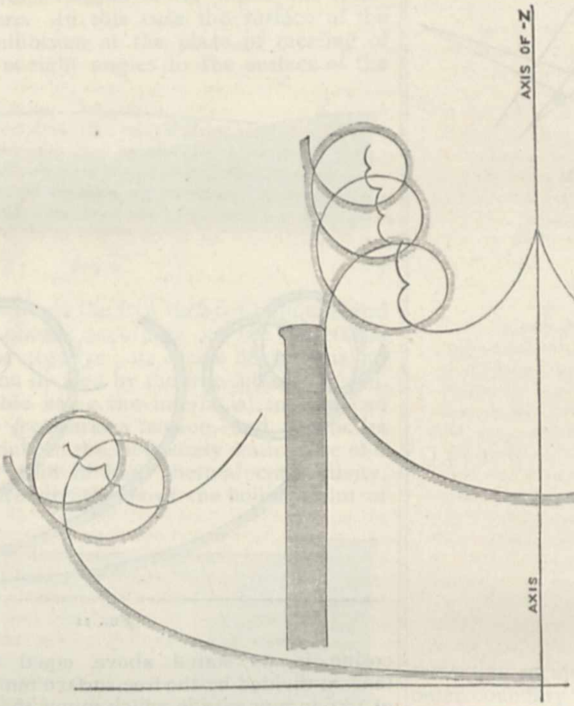

FIG. 12.

WILLIAM THOMSON

(*To be continued.*)

THE SCIENCE AND ART DEPARTMENT EXAMINATION IN CHEMISTRY

THE new editor of the "Science and Art Directory" announces a new departure of the most important kind in the teaching of chemistry. In addition to the oral instruction in the elementary stage, there is now introduced an alternative first stage or elementary course intended for those students who only require the elements of chemistry as a foundation for their studies in other subjects.

We give the new syllabus so that it may speak for itself, and congratulate the Department on a step in harmony with the views of the best friends of scientific education in this country.

SOLUTION.—Disappearance of a solid in a liquid by solution. Saturation of a liquid. Effect of increase of temperature on saturation. Effect of lowering the temperature on saturation. Crystallisation. Filtration. Solvent properties of water. Rain, spring, river, and pond waters, &c. Solid matter in different waters; how estimated. Loch Katrine water. Thames water. Sea water. Hard and soft waters. Mineral waters. Similar solvent of other liquids. Solution of one liquid in another. Liquids insoluble in one another. Solution of gases in water and other liquids. The effect of heat on the quantity of gas dissolved by a liquid.

Experiments.—Suspend a piece of white sugar by a thread in a glass vessel containing water. Dissolve salt in water. Show on a balance that sugar or salt and water when separate and when dissolved weigh the same. Show that salt is obtained

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[1] The diagrams here referred to are now published in Figs. 10 to 24 of the present report of the lecture at the Royal Institution. These figures are accurate copies of Mr. Perry's original drawings, and I desire to acknowledge the great care and attention which Mr. Cooper, engraver to NATURE, has given to the work.

from the solution by evaporation. Saturate water with nitre, and show that the solubility is increased by increase of temperature. Demonstrate the formation of crystals. Illustrate the removal of substances in suspension, and the non-removal of substances in solution by filtration. Show by evaporation the solid matter dissolved in a sample of pump, or river, or spring water, and explain the method for its quantitative determination. Show the like solvent action with other liquids, as calcium chloride, in alcohol and sulphur in carbon disulphide. Compare the result of admixture of spirit or oil of vitriol with water with that of oil or mercury with water. Heat ordinary water and collect the expelled air.

AIR.—Surrounds the globe. Wind is air in motion. Breathing. Air occupies space. The bulk of any quantity of air is much changed by temperature and by pressure. Air has weight. The necessity of air for animals and plants. Bodies when burning require air. Air a mixture of two gases. Oxygen and nitrogen. The proportion of nitrogen to oxygen. Oxygen the active body in air. Bodies burn in it alone and more brilliantly than in air. The combination of oxygen with iron and with other bodies. Increase of weight of bodies which unite with oxygen. Nitrogen does not combine directly with bodies. The nearly constant composition of pure air. Presence of other gases in small amount in air. Water in the air as a gas. The drying up of water.

Experiments.—That air occupies space may be shown by plunging a bell jar into a vessel of water. Fit a flask containing water with an india-rubber plug and delivery tube, heat the water, and collect the expelled air over water. Close the short limb of a syphon tube containing air, and compress the air in the long limb by pouring in mercury. Weigh a flask, fitted with a stop-cock, full of air, and then exhaust by an air-pump, and weigh again. Show that a lighted candle is soon extinguished when burnt under a bell jar, but that it continues to burn if fresh air be from time to time supplied. Burn phosphorus in a tall bell jar over water, and show the diminution of bulk of air. Ignite phosphorus, place it in the remaining gas. Burn some phosphorus under a dry bell jar to show the compound of phosphorus and oxygen which is formed. Place phosphorus in a graduated tube over water to show that at ordinary temperatures it combines with the oxygen of the air and removes it, so that by measuring the volume of gas left, the amount of oxygen contained in air can be roughly determined (to introduce the phosphorus, fuse it in a test-tube under water, and introduce the end of a long wire into it, then let it cool). Burn charcoal and sulphur in oxygen, and call attention to their disappearance. Demonstrate by lime water and by litmus paper that a new body is in each case formed. Burn iron powder (*Ferrum vidactum*) on a scale pan of a balance, to show that an increase of weight occurs. A glass or metal vessel filled with ice or cold water can be used to show the condensation of mixture upon it. Place calcium chloride on the pan of a balance to show the gradual increase of weight which occurs.

WATER.—Its three states. Expansion of water by heat. Equal volumes at different temperatures have not the same weight. Formation of currents in water by heating. Boiling point. Increase of volume on conversion of water into steam. Distillation. Pure water. Hydrogen and its properties. The burning of hydrogen in air, and the weight of the product compared with the weight of the hydrogen; the difference due to oxygen of the air with which hydrogen has combined. Hence oxygen and hydrogen are the constituents of water. Combination of oxygen and hydrogen with explosion to form water. If by measure there be twice as much hydrogen as oxygen, or by weight eight times as much oxygen as hydrogen, then no gas remains—all becomes water. All water composed of these two bodies in this proportion. These two bodies can then be separated from water and can be made to make, unite, and form water. In all cases of chemical combination bodies are united in constant proportion.

Experiments.—Illustrate the characteristic properties of ice, water, and steam. Show that equal volumes of hot and cold water do not counterbalance one another. Fill a flask to the bottom of the neck with cold water, and then heat to show expansion of the water. Show current by heating a large flask of water. To illustrate distillation, distil water containing copper sulphate. Show Liebig's or other forms of condensers. Show the mode of determining the boiling point of a liquid. Show that the temperature remains constant, and that on dissolving substances in water the boiling point is raised. To show the presence of hydrogen in water, pass steam through a red-hot iron tube filled with coarse iron turnings or nails. Water formed of two components, both gaseous. Note the change in the iron both in appearance and weight. This increase of weight and the weight of gas which comes off equals weight of steam which has disappeared. Hence two substances in water, one the combustible gas that comes through the tube, the other the body which remains with the iron. Collect the hydrogen over cold water in proof that it is not steam, also show that it burns. After the tube is cooled show the iron from inside of the tube and explode the oxygen and hydrogen. Plunge a burning taper into jar of hydrogen held mouth downwards, to show burning of the gas and extinction of the taper. Show by a balloon, or soap bubbles, or inverted beaker glass suspended from a balance, that hydrogen is lighter than air. Condense the water formed by the burning of a jet of hydrogen.

Carbon.—Charcoal, graphite, or blacklead and diamond. When wood, sugar, meat, bread are heated carbon remains. Charcoal not changed in the air at ordinary temperatures. Combination of carbon with the oxygen of the air at a red heat. Carbon dioxide a compound of carbon and oxygen. Chemical combination of carbon and oxygen is attended by the evolution of a definite amount of heat expressed by amount of water it will heat. Combustion. The properties of carbon dioxide. Water dissolves carbon dioxide at ordinary temperatures. Action of carbon dioxide on lime-water; no animal can live in this gas. 100 parts of carbon dioxide are composed of 27·27 parts of carbon, and 72·73 parts of oxygen. Carbon dioxide obtained from marble, limestone, oyster-shells, chalk, &c. Charcoal fire. Coal composed of carbon, hydrogen, and a little oxygen, &c.; its burning is the carbon and the hydrogen combining with oxygen. Whenever oil, tallow, coal gas are burnt this carbon dioxide and oxide of hydrogen (water) are formed. Respiration produces similar changes. In expired air the same products arise as from the burning of the food, and there is the same evolution of heat. Carbon a constituent of all animal and vegetable bodies.

Experiments.—Specimens of charcoal. Make charcoal by heating wood in covered crucible. The black lead of a pencil as a specimen of graphite. Sugar heated on piece of tin plate. Show that acids and alkalies do not change charcoal, but that when heated it soon burns away, and only ash is left. Take a small piece of charcoal in a glass tube, pass air over it into lime water, and show no change takes place until the charcoal is made red hot; as the charcoal disappears the lime water becomes milky. Show by means of the balance, or by soap bubbles, or by passing it from one vessel to another, that carbon dioxide is heavier than air, that it acts on lime water, that a burning candle is extinguished in it. Its solubility in water shown by agitating a tube of the gas over water. Prepare the gas from marble by the action on it of dilute acid. Collect all the gas given off from a small piece of marble weighing 5 or 10 grains. Show by collecting in inverted beaker the products of combustion of a candle, of a lamp, and of a gas flame, and adding lime water, that carbon dioxide is given off. Show also by means of lime water that respired air contains this gas.

SULPHUR.—Known also as brimstone. Where found. Its properties. Is also found chemically combined with many metals, so not recognisable by the eye. Sulphur heated in the air melts; more strongly heated it burns, then the sulphur disappears; the strong smell produced belongs to a new body formed by the burning, a compound of sulphur and oxygen. Gaseous properties of the new body, its effect on blue litmus paper, which oxygen and sulphur have not. Its composition is 50·00 parts of sulphur and 50·00 parts of oxygen, and it is called sulphur dioxide. Water dissolves nearly fifty times its volume of this gas, and then turns blue litmus strongly red and has an acid taste. The combination of the gas and water to form sulphurous acid. Another compound of sulphur and oxygen can be made, in which the same weight of sulphur is combined with more oxygen. One hundred parts contain 40 of sulphur and 60 of oxygen, and it is called sulphur trioxide. Sulphur trioxide has properties differing from the dioxide. If the dioxide and oxygen be mixed they do not combine, but if they are passed over hot platinum dense white fumes are formed, which are the trioxide. Combination of the trioxide with water to form sulphuric acid (oil of vitriol).

Experiments.—Show roll and flowers of sulphur and specimen of native sulphur, also iron pyrites and other native sulphides. Powder iron pyrites and heat it in a tube held horizontally over a lamp to show the sulphur obtained from the pyrites. Show the melting of sulphur by heating flowers of sulphur in small flask. Heat sulphur on a piece of tin plate till it catches fire, show the colour of the flame and observe the smell of burning sulphur. Prepare sulphur dioxide by heating copper turnings in sulphuric acid, and show that it extinguishes flame, is very soluble in water, and that the water dissolving it becomes very acid, turning blue litmus red. Bubble air through a strong solution of sulphur dioxide, and then over platinised asbestos; demonstrate that when the platinised asbestos is hot dense white fumes are formed of the sulphur trioxide. Pour some sulphuric acid into 20 or 30 times its volume of water and prove its acid taste, its action on litmus, and its power of causing effervescence if dropped on sodium carbonate. Show that sulphuric acid is a colourless liquid, that bulk for bulk it is much heavier, more than 1¾ times, than water. Show by a thermometer or by immersing a test tube with spirit in it that a large amount of heat is evolved when this acid is poured into water. Pour some on sugar or shake it up with oil to show its action on organic bodies.

Chlorine.—The gas obtained by the action of hydrochloric acid on the black oxide of manganese. So called on account of its colour. Its characteristic smell. Is 2½ times heavier than air and 35½ times heavier than hydrogen. Soluble in water. Many substances take fire in chlorine gas, *e.g.*, phosphorus, and form chlorides. Ignition of oil of turpentine in chlorine with separation of carbon and formation of hydrochloric acid. Bleaching power of chlorine. Bleaching-powder.

Experiments.—Samples of common salt, rock-salt. Prepare chlorine from (1) mixture of common salt, black oxide of manganese and sulphuric acid; (2) from mixture of black oxide of manganese and hydrochloric acid. Collect gas by downward displacement. Draw attention to its colour, and show that phosphorus spontaneously inflames in the gas to form chemical compound of phosphorus and chlorine. Show that oil of turpentine ignites spontaneously in chlorine. Show that sodium when strongly heated burns in chlorine and forms common salt. Show bleaching action of chlorine by dipping moistened Turkey red rag in bottle filled with gas. Show similar action with solution of bleaching-powder and acid. Show that chlorine is soluble in water and that the solution has characteristic smell and colour of the gas.

Acids.—Are bodies which have sour taste, turn blue litmus red, and liberate carbon dioxide when added to solution of sodium carbonate. Sulphuric acid has these properties. Its specific gravity. Colourless when pure. Evolves heat on being mixed with water. There are two other common bodies which have strong acid properties like sulphuric acid, these are nitric acid and hydrochloric or muriatic acid; these are made of different constituents from sulphuric acid. All act on litmus, &c. in same way; all can be neutralised by potash forming potassium sulphate, or nitrate, or chloride. The compound formed by the union of an acid and alkali is called a salt. All three acids are colourless liquids, but, beside the properties possessed by all acids, each acid has properties which belong to it alone. Nitric acid attacks most metals. Poured on copper the metal is dissolved and red fumes are formed. Hydrochloric acid does not dissolve copper, is not so heavy as sulphuric acid; when mixed with manganese dioxide gives off a yellow irrespirable gas known as chlorine.

Experiments.—Samples of both nitric and hydrochloric acid. Show that they have all the properties belonging to acids and that by neutralising them common salt and nitre can be made. Show the action of nitric acid on copper, tin foil, &c. Show that it has no action on platinum or on gold. Copper placed in hydrochloric acid not attacked, but if mixed with manganese dioxide and warmed chlorine is given off.

Alkalies.—Are another class of bodies which turn red litmus blue; have soapy taste and absorb carbon dioxide. If potash be added gradually to sulphuric acid the properties of both bodies gradually disappear, and at last a liquid is obtained that has no action on litmus. The combination of acid and alkali and the body formation of sulphate of potash or potassium sulphate; sulphate of soda or sulphate of ammonia can be formed in a similar manner.

Experiments.—Show that solutions of potash, soda, and ammonia turn reddened litmus blue, and that when a tube containing carbon dioxide is inverted in any of these solutions the gas is absorbed. The taste of these bodies is soapy not sour. Add gradually to dilute sulphuric acid one of these bodies, and see that the acid character of the dilute sulphuric acid disappears. Neutralise exactly sulphuric acid with potash, then evaporate and crystallise out the salt formed.

Ammonia.—A gas with a very pungent smell. Solution in water. One volume of water dissolves 800 volumes of ammonia. This liquid has the pungent smell of the gas, and it can neutralise the strongest acids. Formation of ammonium chloride or sal ammoniac by ammonia with hydrochloric acid. Ammonium chloride a white solid, soluble in water, with no smell of ammonia. Ammonium chloride a volatile body. The effect of boiling a solution of ammonium chloride with lime or potash. Ammonia is composed of 82·3 parts of nitrogen and 17·7 parts of hydrogen. The pungent odour of smelling salts is due to ammonia. Animal matters, such as horn, dried flesh, glue, cheese, isinglass, heated so as to decompose these bodies, yield ammonia. The formation of ammonia in large quantities by heating coal to make coal gas. Production of ammonia when animal matters containing nitrogen putrify.

Experiments.—Prepare ammonia by treating ammonium chloride with an equal weight of slaked lime and enough water to make the whole into a thick mud; and demonstrate its smell, its action on red litmus, and its great solubility in water. The gas passed into water, the increase of volume of the liquid. Its properties and their identity with those of the gas. Volatility of ammonia shown by the liquid leaving no residue on evaporation. Show that ammonium chloride is formed by neutralising a solution of ammonia with hydrochloric acid, and is obtained as a solid on evaporation, and that on further heating it is volatilised. Heat coal in a coarse powder in a glass tube, and show that the liquid obtained is very alkaline. Show the formation of ammonia by the addition of potash and lime to a solution of ammonium chloride.

Lime and Clay.—Limestone, marble, oyster-shells, chalk, all contain a metal known as calcium. The oxide of this metal known as lime. Lime and carbon dioxide are together present in limestone, marble, shells, and chalk. When these are strongly heated, especially in a current of air, the carbon dioxide is evolved and the lime is left. Action of water on lime. Its use in making mortar. Lime slightly soluble in water. On blowing carbon dioxide into a clear solution of lime (lime-water), liquid becomes turbid, owing to combination of carbon dioxide and lime to form chalk. Same effect on breathing through lime-water. Other important salts of lime are gypsum or plaster of Paris (sulphate of lime) and phosphate of lime, which exists largely in bone. Clay is a combination of a body called silica, which is the chief constituent of sand and flint, with the oxide of a metal known as aluminium, so called because it exists also in alum. Glass is a compound of silica with lime and an alkali, potash or soda. Varieties of clay; their use in manufacture of bricks and pots. The metal of clay (aluminium), a white body with a brilliant lustre, 2½ times heavier than water; may be rolled out into thin sheets and drawn into fine wire. Not oxidised in the air.

Experiments.—Samples of limestone, marble, oyster shells. Show that these substances effervesce with dilute hydrochloric acid, and that a gas carbon dioxide is evolved. Heat a piece of limestone or marble to redness in a fire, and show that after heating it no longer gives off carbon dioxide on treatment with an acid. Describe process of lime-burning. Properties of lime as distinguished from limestone. Show that a piece of moistened red litmus paper pressed against limestone is not affected, but that when pressed against lime it is turned blue. Show slaking of lime; draw attention to heat evolved. No such result on treating limestone with water. Show that lime is soluble in water, whereas limestone is not. Add carbon dioxide to the solution of lime, and show that white powder is formed which on treatment with acid evolves carbon dioxide again. Explain that white powder thus formed is identical in chemical composition with limestone, and hence that limestone is a compound of carbon dioxide and lime. Explain use of lime in making mortar. Various samples of clay are used in manufacture of bricks and pots. Show plasticity of clay and exhibit one or two specimens of ware before being baked. Show that a vessel of kneaded or "puddled" clay will hold water. Explain chemical nature of clay, and show specimens of silica and alumina. Show alum and demonstrate that alumina is contained in it by heating ammonia alum. Show specimen of aluminium and explain that this metal is contained in alumina and therefore in clay.

Metals, Introductory.—About 70 different elementary subjects known. Almost all the common metals are elements. For instance, iron, lead, copper, zinc, mercury, silver, gold, tin, are elements. All combine with oxygen to form oxides, with chlorine to form chlorides, and with sulphur to form sulphides.

Experiment.—Specimens of metallic and non-metallic elements and of oxides and sulphides.

LEAD.—Its colour; a fresh surface bright, but soon tarnishes in the air. Is heavy. Lead is 11½ times heavier than water. Can be beaten or rolled into thin sheet or drawn into wire. Melts at temperature 633° F. Can be cast in a mould. Its combination when liquid with oxygen. Formation of lead oxide. The oxide has entirely different properties from lead. Removal of the oxygen when heated with carbon and the formation of metallic lead. Formation of red lead by heating the oxide. Solution of lead by nitric acid and the formation of lead nitrate. Solution of lead oxide by nitric acid and the formation of lead nitrate. Similarly to potassium nitrate this is to be termed "a salt." Its solution in water. Other salts of lead, chloride, sulphate. Formation of sulphate and chloride of lead, their insolubility in water. Galena, or lead sulphide, one of the ores from which lead is obtained.

Experiments.—Piece of lead to scrape and show it is then bright and has "metallic" appearance. Show by balance that compared with water it is bulk for bulk much heavier. Show the metal beaten out into thin sheet, also as wire. Melt lead in an iron spoon, and cast in a mould. Show formation of oxide by blowing air on to the melted metal. Contrast the properties of the oxide with those of the metal. Convert the oxide again into metal by strongly heating an intimate mixture of it and charcoal powder. Heat the oxide to show its further oxidation and the formation of red lead. Show the action of nitric acid on lead, also on lead oxide, and the formation of lead nitrate. Show this is "salt," and prove that it is soluble in water. Demonstrate that the first is very slightly soluble, and the last almost insoluble in water. Show the formation of chloride and sulphate of lead by the addition of the respective acids to a solution of lead nitrate. Collect on filter the salts so formed, wash and dry them. Show specimen of Galena (lead sulphide).

IRON.—Not used in a pure condition, always obtained united with carbon. Three kinds of iron; wrought iron, cast iron, and steel. Wrought iron the purest and used if the body is to be formed by hammering. Cast iron contains most carbon. Steel used for cutting instruments; can be made into a magnet; can be "annealed." Solubility of all three forms of iron in sulphuric, nitric, and in hydrochloric acids, and the formation of iron sulphate, nitrate, and chloride. Their solubility in water. Melting point of iron is at much higher temperature than that of lead. Comparison of the weight of iron with that of water. Its colour. The ready action of air on it. Formation of rust. Oxidation by heating. The action of steam on iron when red hot. Oxide of iron heated with hydrogen or with carbon parts with its oxygen, and iron is left. Oxide of iron found in the earth. Hæmatite. A carbonate of iron mixed with clay used as a source of iron. Heating the ore the iron is converted into oxide. Removal of the oxygen by heating it to a very high temperature with carbon. Formation of slag from clay and lime.

Experiments.—Specimens of the different kinds of iron, wrought iron, cast iron, and steel. Dissolve cast iron in hydrochloric acid diluted with equal volume of water, show carbon which remains, filter and evaporate the liquid to show the chloride of iron formed. Heat iron wire by the blowpipe to show the high temperature required to fuse it. Iron acted on by air and moisture to show its rusting. Heat iron oxide in a tube and pass hydrogen over it to show formation of water and metallic iron. Show specimens of iron ores, clay iron stone. Hæmatite magnetic iron ore, and slag.

COPPER.—Its colour. Does not rust in air at ordinary temperatures. Thin wire melts in flame of Bunsen burner. When heated in air becomes black, owing to formation of an oxide. Oxide heated in hydrogen gas yields up its oxygen, water is formed, and the red-coloured copper is obtained. Action of acids on copper. With dilute nitric acid evolves a colourless gas, which turns red in contact with the air, and the metal dissolves, forming a green solution of copper nitrate. Heated with sulphuric acid copper yields sulphur dioxide, the same gas which is formed when sulphur burns in air or in oxygen. Substance formed when copper dissolved in sulphuric acid is when crystallised from water of a fine blue colour, known as copper sulphate or blue vitriol. Action of vegetable acids on copper. Verdigris. Use of copper in alloys. A penny composed of 95 parts of copper, 4 parts of tin, and 1 part of zinc. Bell metal and gun metal contain copper and tin.

Experiments.—Show specimens of copper in bar, sheet, and wire. Point out characteristic colour of metal. Heat piece of sheet copper over flame of Bunsen burner. Show formation of black film. Explain its origin. Take black oxide of copper and heat in hydrogen gas. Show that metal is again formed and that water is produced. Show action of nitric and sulphuric acids upon copper. Exhibit specimen of copper sulphate (blue vitriol). Show that on placing a knife blade in a solution of copper sulphate metallic copper is formed on the steel. Show sample of vèrdigris and explain how formed. Show various alloys of copper, bell-metal; brass, gun-metal, &c., a penny-piece.

MERCURY.—A liquid metal, but if it be cooled to - 40° Fahrenheit it is solid. Its metallic appearance. Its weight; heaviest liquid known; 13·6 times heavier than water. Use in the barometer and thermometer. Does not rust or tarnish in the air at ordinary temperatures, oxidation if heated to about 600° F. in the air, and the formation of red mercuric oxide. Is readily attacked and dissolved by nitric acid. It dissolves many metals, —*e.g.*, tin, lead, &c.; amalgams. Mercury in combination with sulphur, as cinnabar. Mercury can be obtained from any salt of mercury by heat, volatilization of mercury, and the condensation of the vapour.

Experiments.—Specimen of mercury. Show that to balance a given volume of mercury 13½ volumes of water are necessary. Boil a little mercury in a tube to show it vaporizes. Treat mercury with nitric acid and show its solution. Show that tin foil is dissolved by mercury, which becomes less fluid. Heat mercuric oxide in a tube and collect both the oxygen and the mercury. Heat mercuric chloride in tube sealed at one end with dry sodium carbonate and show the metallic mercury condensed on the side of the tube.

SODIUM.—Common salt contains a metal combined with chlorine known as sodium. 100 parts of common salt contain 39·3 parts of Sodium and 60·7 parts of Chlorine. Carbonate of soda (washing soda) contains sodium. Sodium obtained on strongly heating carbonate of soda with charcoal. Sodium one of the lightest solids known. Swims on the surface of water and decomposes that liquid with evolution of hydrogen and formation of the alkali soda. Other properties of the metal sodium: its low fusibility and softness. Its tarnishing in air. Preservation of sodium from action of air by being kept in same liquid lighter than water and free from oxygen.

Experiments.—Samples of common salt and rock salt; also washing soda and bicarbonate of soda. Recall experiment showing that chlorine is constituent of common salt. Show that washing soda and sodium bicarbonate evolve carbon dioxide on treatment with an acid. Common salt a compound of chlorine with a metal called sodium; bicarbonate of soda and washing soda compounds of carbon dioxide and sodium. Sodium can be made by strongly heating sodium carbonate with charcoal. Exhibit specimen of portions sodium. Show that it can be cut with a knife, and that the so cut can be pressed together again. Exhibit metallic lustre of sodium; show that it quickly tarnishes in the air. Show that sodium is lighter than water and decomposes that liquid with evolution of gas (hydrogen). Collect hydrogen from water by thrusting small piece of sodium beneath test-tube filled with water and standing in basin of water.

CARBON COMPOUNDS.—Large numbers of substances are met with in plants and animals which are not found in the earth. Most of these bodies contain carbon. The other elements united with the carbon are hydrogen, oxygen, nitrogen; some bodies are composed of all these elements; others of only two of them. Many of these bodies when heated leave black residue of carbon; when this is more strongly heated it burns away. The great number of these carbon compounds, and the great difference in their properties. Some are acids, *e.g.*, vinegar (acetic acid), and tartaric acid. Some are salts, *e.g.*, fats, tallow, butter. Some are neutral bodies, *e.g.*, sugar, starch, spirit.

Experiment.—Show that on heating any ordinary vegetable or animal substance carbon is left behind.

ACETIC ACID.—One form of dilute acetic acid is known as vinegar. Formation of acetic acid when beer or wine exposed to the air becomes sour. The spirit present combines with oxygen of the air and forms acetic acid. The presence of a kind of fungus called *mycoderma aceti* necessary to cause this oxidation. Large amount of vinegar is made from poor kinds of wine and beer. Action of vinegar on blue litmus, and on sodium carbonate. Vinegar is also made by heating wood in a retort; a great many bodies distil over, among them acetic acid. The pure acid has very pungent smell, and has all the properties which are characteristic of the acids. Boils at 246° F. Dissolves in water. It is composed of carbon, hydrogen, and oxygen in the proportion of 40·0 parts of carbon, 6·7 parts of hydrogen, and 53·3 parts of oxygen. It is neutralised by alkalies like sulphuric acid. Iron put into it is slowly dissolved, hydrogen being given off. Oxide of lead dissolves in it, forming a salt, and if the clear solution be evaporated a white crystalline body called "sugar of lead" is formed, which is lead acetate. The vinegar smell belongs only to the acid, not to the salts. Sodium acetate has no smell; add to it sulphuric acid and warm, when the smell shows the acid has been liberated and that it is volatile.

Experiments.—Show that vinegar has the properties of an acid, and that a salt is formed on neutralising it. Show a specimen of the commercial acetic acid, and point out its colourless appearance and strong smell and acid reaction. Show that iron is acted on and dissolved by acetic acid. Make sugar of lead by dissolving lead oxide in acetic acid, and crystallise out the salt. Point out disappearance of the pungent odour of the acid on neutralisation by potash or soda. Demonstrate the liberation of the acid as indicated by the odour on addition of sulphuric acid to sodium acetate, and show that it can be separated from the liquid by distillation.

TARTARIC ACID.—Occurs in many fruits; especially in grapes. Is obtained from "argol," an impure potassium salt of tartaric acid, deposited when grape juice ferments. Tartaric acid is a crystalline solid, and dissolves easily in water. Has no smell. Is composed of carbon, hydrogen, and oxygen, *i.e.*, the same elements as are in acetic acid but in different proportions, viz.: 32·0 parts of carbon, 4·0 parts of hydrogen, and 64·0 parts of oxygen. Its action on sodium carbonate. Effervescing draughts; seidlitz powders. Tartrates.

Experiments.—Specimen of argol and of crystals of tartaric acid. Show solubility of the solid acid in water, and that the solution has acid properties and is without odour. Demonstrate the presence of carbon in the acid by ignition.

FAT AND OILS.—Are neutral bodies made up of an acid and a base, the base in all cases is glycerine, the acid varies in different oils and fats. They are all insoluble in water. Oils are liquid; fats are solid. Many of the oils are obtained from vegetables, either from the seed or fruit. Most of the fats are from animals. Melting of tallow (fat of the ox, sheep, &c.) put in boiling water. Its non-solution in water. Its lightness as compared with water. If a solution of caustic potash be added, and the solution of the liquid boiled, the fat disappears and the liquid becomes slightly milky, and nearly the whole dissolves. Combination of the potash with the acid (stearic) of the tallow and formation of potassium stearate. Previously the stearic acid was combined with glycerine. To the solution of potassium stearate hydrochloric acid is added. The potash is again separated from the stearic acid, and the stearic acid, as it cannot dissolve in water, separates out. Stearic acid dissolves in alcohol and in ether and separates out in crystals. Used in making candles, and is better than tallow because it melts at a higher temperature. Tallow distilled with steam of temperature 600° F. (high pressure steam) separates into stearic acid and glycerine, and when cold these bodies remain separate. All oils and fats are decomposed by potash in the same way as tallow.

Experiments.—Tie beef or mutton fat up in muslin bag, and melt to separate the fat from membranous matter. Show that fat is insoluble in water, that it floats on water, and melts at a temperature below boiling water. Show that oil has very similar properties to melted fat. Boil oil or fat with caustic potash. Prepare a solution of potassium stearate, and precipitate stearic acid from it by the addition of hydrochloric acid. Show the solubility of the acid in alcohol and ether, and the insolubility of the lime salt of stearic acid.

GLYCERINE.—A thick colourless liquid with a sweet taste. Dissolves readily in water. When quite pure becomes solid at a low temperature. If heated alone it is destroyed, but if heated with water in a retort it distils over with the steam. Heated with acids it combines with them, and bodies similar to fats are formed.

Experiment.—Specimen of glycerine. Demonstrate its solubility in water and its sweet taste.

SOAP.—By boiling fat with caustic soda sodium stearate is formed. On adding salt to the liquid the sodium stearate, which is soap, separates out and solidifies on the surface of the liquid. Soft soap is potassium stearate. Action of soap in washing. Action of soap on hard and on soft waters.

Experiment.—Shake distilled water up in bottle with soap. Show action of solution of salts and acids on the solution. Add soap solution to distilled water, also to common water, and explain the difference of action. Show the presence of stearic acid in soap by adding hydrochloric acid to a solution of soap.

SUGAR.—Exists in many plants. Is obtained from the sugar-cane; also from beetroot. The juice of these plants yields the sugar. When pure it is white, crystalline, sweet, and very soluble in water. Sugar candy. If heated with very little water to 365° F., on cooling it is no longer crystalline and is "barley sugar." Does not combine with acids, but even a very little acid boiled for a long time with a solution of sugar changes it to another kind of sugar. Composition of cane sugar. The several different kinds of sugar, *e.g.*, the solid part of honey is a sugar which differs from the sugar in the sugar-cane; the same found in all sweet fruits and is called grape-sugar. Grape-sugar not so sweet nor so soluble as cane-sugar.

Experiment.—Specimens of ordinary white and brown sugar; also sugar candy and barley sugar. Show its great solubility in water; also that its solution is neutral. Heat it and point out the peculiar odour it gives out, and that on further continuing the heat it leaves a residue of carbon. Wash honey with spirit, and show the residue is sugar, but that it is not sweet as ordinary sugar, and not so soluble.

STARCH.—A neutral substance, composed of carbon, hydrogen, and oxygen. Composition. Peculiar structure; not crystalline. Is found in all parts of a plant. Is obtained from wheat, rice, potatoes, arrowroot, &c. Starch in its ordinary condition insoluble in water. When starch powder is boiled with water, the membrane of starch cells bursts, and the starch is partially dissolved. Strong solutions form a jelly when cold. Used for stiffening linen. Starch recognised by its forming a blue compound with iodine. Undergoes no change in the air at ordinary temperatures; if heated to about 300° F. it becomes slightly discoloured and is changed into a soluble body, known as British gum (dextrin). If small amount of nitric or hydrochloric acid be added to the starch this change is more rapid. Extract of malt also changes starch into soluble compounds. Starch as a food.

Experiment.—Specimen (of starch), point out its peculiar structure and absence of crystalline form. Demonstrate that it does not dissolve in cold water, but on boiling some does dissolve. Show that starch both solid and in solution gives a blue colour when iodine is added to it. Moisten starch with very dilute hydrochloric acid, and heat to convert it into a gum, which is thus soluble in water.

GLUTEN.—If flour is tied up in a calico bag and well kneaded in a basin of water, the water becomes milky, and on standing starch sinks to the bottom. All the starch in the flour can thus be removed, and then a sticky substance remains in the bag called gluten. About 70 per cent. of flour is starch and 10 per cent. is gluten. Gluten contains nitrogen, starch does not. These bodies represent two most important constituents of food. The gluten exposed to the air soon decomposes and smells very disagreeably (putrifies).

Experiment.—Tie some flour up in a piece of calico and knead it for some time in a vessel of water; the starch comes through, and will settle to the bottom of the vessel, and can be collected and examined; the gluten remains in the bag.

SPIRIT.—Alcohol, spirits of wine. A colourless, light liquid. Neutral to test papers. Has pleasant odour, boils at 173° F. Burns with a flame, which gives very little light, without leaving any black residue of carbon. A large number of different bodies dissolve in it. It is the intoxicating principle in wines and spirits. In beer there is 3 to 5 per cent. of alcohol. In light wines about 8 per cent. In spirits 60 to 75 per cent. The different flavours of wines and spirits depend on very small quantities of other bodies present. Alcohol dissolves in water, giving out heat.

"Proof spirit" contains 50·76 parts of water, and 49·24 parts of alcohol. If more water be present the spirit will not set fire to gunpowder when burning. Alcohol obtained from grape sugar. Fermentation grape sugar converted into alcohol and carbon dioxide by presence of some ferment which exists in yeast. Cane sugar on the addition of yeast is first converted into grape sugar, then into alcohol and carbon dioxide. Use of yeast in brewing. Not necessary for making wine, as there is already a ferment in expressed juice of grape.

Experiment.—Show it is neutral liquid dissolving in water, that it burns with nearly colourless flame, and leaves no residue of carbon. Show that it can be made to boil at much lower temperature than water by placing test-tube of it in hot water. Distil beer and collect the alcohol and water which comes over;

add quicklime to this. Allow it to stand some hours, and distil again. Show that this is much stronger, catches fire readily, and tastes more burning. Make a solution of common sugar in a large flask; add yeast, and fit a cork with a bent tube to the flask. Let the tube dip into lime water. Place it in a warm place, and after some days show that spirit has been formed in the flask by distilling the liquid and collecting the portion coming over first.

All the substances and experiments mentioned above are to be shown to the class. This does not preclude such other experiments and illustrations as may suggest themselves to the teacher.

NOTES

WE trust that it is not in the least likely that the proposal "From a Correspondent" in Saturday's *Times* to remove the Science Museum to make way for a permanent Colonial Museum will receive serious attention in any influential quarter. For this proposal really involves the monstrous step of shunting collections which have been brought together with so much trouble and at so much expense. Their value was recognised by the Duke of Devonshire's Commission. As to the Colonial Museum we shall be in a better position to express an opinion upon it when its nature and objects are further developed. We wish in no way to disparage it; but there is room for it elsewhere. Why should its founders try to build it on the ruins of an existing and valuable collection?

THE thirty-fifth meeting of the American Association for the Advancement of Science will be held at Buffalo, from Wednesday, August 18, until Tuesday evening, August 24, 1886. For the third time, at intervals of ten years each, the Association has accepted an invitation to hold a meeting in Buffalo. The Local Committee intend to make the meeting a great success: and members who were at the meeting of 1876 need only to recall it in order to form an idea of what the coming meeting promises to be. The facilities which the city offers are all that can be desired, both in regard to rooms for the several Sections and in hotel accommodation, while the health and comfort of the city in the month of August are well known. The headquarters of the Association will be at the High School, and all the offices and meeting-rooms will be in that building or in one of the schoolhouses near by. The hotel headquarters will be at the Genesee House. A special circular in relation to railroads, hotels, and other matters, has been issued by the Local Committee. Arrangements for excursions and receptions will be announced by the Local Committee. The officers of Sections D and H have issued special circulars relating to the meeting, which can be had by addressing the respective secretaries. Special information relating to any of the Sections will be furnished by their officers. In Section E special attention will be given to the problems connected with the Niagara Falls and its gorge.

WE have only just received the *Proceedings* of the American Association for the Advancement of Science at the Philadelphia meeting of 1884. The volume is particularly well printed and fully illustrated.

THE Institution of Naval Architects is holding a summer meeting at Liverpool this week.

THE recent elections have done nothing to alter the comparatively small but distinguished band of men of science in the House of Commons. Sir John Lubbock retains his seat for London University. The electors of South Manchester have remained faithful to Sir Henry Roscoe, and those of South Leeds to Sir Lyon Playfair. Mr. Story-Maskelyne returns from North Wiltshire, and Sir Edward Reed, after one of the principal contests of the election, from Cardiff.

M. JANSSEN is continuing, at Meudon, his researches on the influence of gases on the rays of the spectrum. He is building tubes, which can be loaded with 1000 atmospheres of hydrogen, oxygen, or carbonic acid. In this last case the real density of the gas will be superior to the density of water. The filling of the tubes to these high pressures is not directly obtained by pressure; they are loaded by a sort of step-by-step or cascade process. This is a very long affair. After the filling of these tubes some time must be allowed for the settling down of the dust which has been raised by compression. As long as the cloud of minute particles is floating, the colour of the light traversing longitudinally the tubes is blood-red. This effect can be shown with a far lessened pressure.

MR. J. M. HORSBURGH has been appointed Secretary of University College, London, to enter upon his duties on October 1.

DURING the last ten years M. Marcel Deprez has been engaged in experiments connected with the transmission of force by means of electricity. The Rothschilds some time since provided him with an unlimited credit to prosecute his researches at Creil, under the inspection of a commission of thirty-eight men of science. On Friday the commission met to hear a report on the results at present obtained, drawn up at their request by M. Maurice Lévy. This report was unanimously approved. It appears from it that we can now, with only one generator and only one receiver, transport to a distance of about 35 miles a force capable of being used for industrial purposes of 52-horse power, with a yield of 45 per cent., without exceeding a current of 10 ampères. When the amount of force absorbed by the apparatus used to facilitate the recent experiment, but not required in the applications to industrial purposes, is added, the yield will be nearly 50 per cent. The commission certifies that the machines now work regularly and continuously. The maximum electromotive force is 6290 volts. Before the construction of the Marcel Deprez apparatus the maximum force did not exceed 2000 volts. The report states that this high tension does not give rise to any danger, and that no accident has occurred during the past six months. The commission is of opinion that the transmitting wire may be left uncovered on poles provided it be placed beyond the reach of the hand. It estimates at nearly 5000*l.* the probable cost of the transmission of 50-horse power round a circular line of about 70 miles. This price would, however, be much diminished if the machines were frequently constructed. The commission, in the name of science and industry, warmly congratulated M. Deprez on the admirable results which he had obtained, and expressed thanks to the Rothschilds for the generous aid extended to the undertaking.

THE eighth congress of the French Geographical Societies will meet at Nantes on the 4th proximo, and will continue until the 9th.

IT is stated that Baron de Miklouho-Maclay is now busy getting printed at St. Petersburg, by command of the Czar, the result of his scientific researches in New Guinea from 1870 to 1883.

A CONFERENCE was held by the National Fish Culture Association on Monday last at the Colonial and Indian Exhibition. Sir Albert K. Rollit, M.P., presided. The chairman, in delivering the presidential address, stated that the Association had made a great impression upon the public as to the necessity for remedial, protective, and other measures in the interest of our fishing industries and population. The Association was doing work which many other nations and colonies thought it expedient and economical to do upon a much larger and more expensive scale. He therefore thought the public ought to support it liberally in order to enable it to carry out the work which could not be left undone without serious danger to one of the greatest industries of this country. Mr. Oldham Chambers then read a paper upon "Carp Culture," which was followed by the Rev. C. J. Steward with a paper upon "Marine Temperatures and their Influence upon Fishes," and Mr. Willis-Bund with a paper upon "The Influence of the Weather upon the Migration of Fish." After the several papers had been fully discussed, the proceedings terminated with a vote of thanks to the chairman for presiding.

IN a recent article the *Ceylon Observer* refers to the power of the coco-nut palm to conduct lightning. Sir Emerson Tennent long ago pointed out that this tree acts as a conductor in protecting houses from lightning, and in one instance 500 palms were struck in a single plantation during a succession of thunderstorms in April 1859. But the trees themselves suffer terribly in the process, for however slightly they may be touched by the electric fluid, they die. Sometimes only the edges of the branches are singed, at others a few leaves turned brown alone show where the tree was touched, yet however slight the apparent effect, in course of time the tree withers gradually and dies. In conclusion the journal quoted inquires why it is that coco-nut palms which have merely had their external parts, their foliage, almost imperceptibly singed should be as much doomed to death as those which have had their vital parts permeated by the lightning, the fatal result being only protracted in the one case, while it is instantaneous in the other.

AT Nottingham the University College, Technical Schools, and a Museum are under the same committee as the Free Library; and from the not very carefully edited Report of that committee the convenience of combination is further shown by special classes being opened at the first of them for elementary school teachers, while the expense is defrayed by the School Board. The Technical Schools, whose evening class students we trust will far exceed in number the regular daily pupils, are largely supported by voluntary contributions from the Drapers' Company; so natural and appropriate a use to put such money to, that it is to be hoped that the reforming spirit of the age will lead to the same commendable action voluntarily on the part of all such old trade guilds. As might easily have been foreseen, commercial classes held during the working hours of all those who felt their need have failed; just like the free library at the Guildhall, London, so discreetly opened at first from ten till four—just the hours when the pressure of business was greatest upon every one to whom it could be of any use! An experience of the Nottingham Committee seems to be that the highest working power of their money may be obtained by opening district branches, modestly termed reading rooms, yet each the germ of a branch library; and also that the most economical size for a free library, as far as supplying literature to the working classes is concerned, is from three to four thousand volumes; their libraries of that size having a greater circulation in proportion than either the larger or the smaller ones.

WE have received the first number of a new technical journal named *Industries*, published in Manchester. As its name implies it is the intention of the publishers that it shall cover all the ground of the manifold manufactures of the country, and include the dissemination of technical education in its widest and most useful form. A new departure is taken in technical journalism, inasmuch as the publishers propose to offer a series of substantial rewards to those of their readers who may bring forward some new and useful advance in practical science. These awards will be granted on certain conditions being fulfilled, and will be made by the editors, assisted by two or more gentlemen eminent in the particular science. As a commencement it is the intention to arrange rewards in each of the following subjects, viz. engineering, electricity, and chemistry. In order to increase the value of the reward, and should the successful reader desire it, a patent will be obtained by the publisher for the invention or process, which will be presented to the successful reader before the invention is described in the paper, and further, if a model is necessary, this also will be added to the reward. This inducement ought to add considerably to the subscribers' list, and ensure the success of the paper; at the same time it will without doubt increase, the number of workers and probably add to the already large list of inventions. The paper is nicely printed, and the woodcuts are well executed. We find an illustrated Patent record at the end of the journal, and arrangements are to be made so as to include the more important American and German Patent Specifications. Journals of this class add greatly to the general advancement of technical education, and we wish the new venture every success in its youth and a strong and sturdy future.

A MOSCOW journal states that it is contemplated establishing a university for women in that city, founded on private capital. It is to have three faculties—a mathematical, a natural history one (with medicinal studies), and a philological. Doubt is, however, expressed whether the Government will sanction the scheme.

FROM several parts of Western Norway complaints are being received of the great destruction of fir and spruce cones by a little unknown insect.

FROM the report of the Swedish Academy of Sciences for last year, it appears that the National Museum—which is under the authority of the Academy—succeeded in acquiring some splendid specimens of topazes from Brazil, containing fluids on which experiments are now in progress in the Academy's chemical laboratory. Some specimens of argyrodite, containing the new element germanium, were also acquired, with which Profs. Nilsson and Petterson have been experimenting. The museum for lower invertebrates acquired from Lieut. Sandberg a very valuable collection of lower marine animals from the shores of Northern Russia, collected by this gentleman during his extensive journeys in these parts. At the Academy's biological station on the coast of the province of Bohus, aquaria were kept in perfect working order from June till October. The station was visited by many *savants* for zoological studies. Through Dr. Carlson's researches on the former existence in Sweden of *Trapa natans*, the National Museum has become possessed of more than a thousand sub-fossil trapa fruits from Southern Sweden. In addition to the sums granted by the Government towards scientific researches on the recommendation of the Academy (p. 201), several others were made out of the funds administrated by that institution. Among them are the interest on the large sum left by the late Dr. Regwell for zoological studies, distributed for the first time; a sum of 250*l.* to Dr. S. Arrhenius for the study of the galvanic conductive force of electrolytes, and their relation to physics, at certain institutions in Russia, Germany, and Holland. Prof. Agardh was awarded the yearly Lettersted prize for his celebrated work "Fresh contributions to the Systematic of the Algæ." The Lettersted fund for scientific research amounted at the end of the year to 30,000*l.* A number of smaller sums were also granted by the Academy towards researches on a variety of scientific subjects.

MR. OTIS T. MASON sends us a reprint of his valuable paper on the progress of anthropology in 1885, which was originally embodied in the Smithsonian report for that year. Here anthropology is used in a very wide sense, giving scope to remarks on comparative psychology, biology, archæology, and sociology, as well as to the more closely-connected subjects of general and special ethnology. Some of the more important recent works on these several branches are noticed in greater or less detail, and there is appended an ample "Bibliography of Anthropology, 1885," which is arranged in alphabetical order, and which will be found most useful for purposes of general reference. It includes not only independent works and memoirs, but also special papers bearing on the subject, which have been contributed in the specified period to various English, American, French, German, and other scientific journals. Amongst the essays more fully noticed are M. Gabriel de Mortillet's work on "The Precursor of Man," advancing the theory that the flints of Thenay were the workmanship, not of man as fully developed, but of his immediate predecessor, the anthropopithecus; Dr. Lissauer's paper on human craniology, introducing the sagittal suture as a new element in obtaining anthropological measurements; Dr. Hermann Welcker's treatise on the capacity of the cranium in connection with the three diameters, with classifications of races according to their skull capacity; Dr. Topinard's masterly work on general anthropology, from which copious extracts are made; Dr. Otto Stoll's contribution to the comparative philology of Central America, embodying a scientific classification of the eighteen languages still current in Guatemala. Here the Maya family is specially dealt with and divided into four distinct groups: Tzental (Chendal), Pokonchi, Quiché, and Marne. It is incidentally mentioned that in 1885 the Woman's Anthropological Society was organised in Washington under the presidentship of Mrs. Tilly Stevenson. The object of this association is stated to be "to conduct investigations to which the avenues are especially open to women, and to encourage the sex in the prosecution of scientific work."

THE catalogue of the Library of the Chemical Society, arranged according to subjects with indexes containing authors' names and subjects, will be useful to chemists.

VOL. I. of "Studies from the Biological Laboratories of the Owens College" (Manchester: Cornish) is mainly a reprint of papers that have appeared in various journals.

WE have received the last (19th) Report of the Peabody Institute of Baltimore. There is no marked advance over past years in any department, but all have been prosperous and the results attained have been satisfactory. The attendance at the courses of lectures was exceptionally large, but the use of the library has been somewhat reduced owing to the opening of another free public library in Baltimore. Amongst the lectures during the year were courses on Arctic Explorations and Life in the Arctic Regions, on Mexico, Ancient and Modern, on the Mound Builders of Ohio, and on the Poetry of Science.

MR. C. G. ROCKWOOD, jun., of Princeton, N.J., writes that the shock of earthquake at Sandy Hook, New York, of June 11, noticed in NATURE of June 17 (p. 153) is an error. The tremor which was felt in that vicinity at the time stated, and which was at first reported as an earthquake, was afterwards traced to the firing of heavy guns on board the U.S.S. *Juniata*, at that time approaching Sandy Hook.

THE additions to the Zoological Society's Gardens during the past week include a White-handed Capuchin (*Cebus hypoleucus*) from Brazil, presented by Madam Sangiorgi; a Levaillant's Cynictis (*Cynictis penicillata* ♂), five Suricates (*Suricata tetradactyla* ♂ ♂ ♀ ♀ ♀), two Triangular Spotted Pigeons (*Columba guinea*), three Vinaceous Turtle Doves (*Turtur vinaceus*), two Cape Turtle Doves (*Turtur capicola*) from South Africa, presented by Mr. R. A. Fairclough; two Red Foxes (*Canis fulvus* ♂ ♀) from North America, presented by Messrs. Enson, Weber, and Co.; a Masked Paradoxure (*Paradoxurus larvatus*) from Hong Kong, presented by Mr. J. Orange; five Forster's Milvagos (*Milvago australis*) from the Falkland Islands, presented by Mr. James Moore; a Tawny Owl (*Syrnium aluco*), British, presented by Master C. G. Gregory; five Common Toads (*Bufo vulgaris*) from the South of France, presented by Mrs. F. Walker; a King Vulture (*Gypagus papa*) from Brazil, deposited; three Lions (*Felis leo* ♂ ♀ ♀) from Africa, a Grey Squirrel (*Sciurus cinereus*), a Mink (*Putorius vison*), three Hudson's Bay Squirrels (*Sciurus hudsonius*), a Virginian Eagle Owl (*Bubo virginianus*) from North America, purchased; two Mule Deer (*Cariacus macrotis* ♂ ♂), born in the Gardens.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1886 *AUGUST* 1-7

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on August 1

Sun rises, 4h. 26m.; souths, 12h. 6m. 4·9s.; sets, 19h. 46m.; decl. on meridian, 17° 59′ N.: Sidereal Time at Sunset, 16h. 27m.

Moon (one day after New) rises, 5h. 59m.; souths, 13h. 19m.; sets, 20h. 26m.; decl. on meridian, 11° 23′ N.

Planet	Rises h. m.	Souths h. m.	Sets h. m.	Decl. on meridian ° ′
Mercury	6 43	13 26	20 9	7 52 N.
Venus	1 45	9 54	18 3	22 29 N.
Mars	10 55	16 23	21 51	7 0 S.
Jupiter	9 27	15 31	21 35	0 5 N.
Saturn	2 21	10 28	18 35	22 10 N.

Occultations of Stars by the Moon (visible at Greenwich)

Aug.	Star	Mag.	Disap. h. m.	Reap. h. m.	Corresponding angles from vertex to right for inverted image ° °
5	95 Virginis	6	21 54	22 53	108 297
5	94 Virginis	6	22 3	near approach	202 —

Aug.	h.	
1	15	Mercury stationary.

Variable Stars

Star	R.A. h. m.	Decl. ° ′			h. m.	
U Cephei	0 52·2	81 16 N.	Aug.	2,	22 30	*m*
λ Tauri	3 54·4	12 10 N.	,,	3,	22 12	*m*
U Monocerotis	7 25·4	9 32 S.	,,	6,		*M*
S Virginis	13 27·0	6 37 S.	,,	1,		*m*
V Coronæ	15 45·5	39 55 N.	,,	5,		*M*
U Ophiuchi	17 10·8	1 20 N.	,,	2,	0 38	*m*
R Scuti	18 41·4	5 50 S.	,,	1,		*M*
η Aquilæ	19 46·7	0 43 N.	,,	5,	21 30	*m*
δ Cephei	22 24·9	57 50 N.	,,	4,	0 0	*m*

M signifies maximum; *m* minimum.

Meteor Showers

Showers have been observed at this season from the following radiants:—The *Andromedes* (I.), from R.A. 8°, Decl. 36° N.; from Camelopardus, R.A. 12°, Decl. 70° N.; near η Persei (the *Perseids*), R.A. 45°, Decl. 56° N.; near η Herculis, R.A. 254°, Decl. 37° N.; near λ Aquarii, R.A. 342°, Decl. 9° S.; from Lacerta, R.A. 342°, Decl. 40° N.; and one near Fomalhaut, R.A. 342°, Decl. 34° S.

Stars with Remarkable Spectra

Name of Star	R.A. 1886·0 h. m. s.	Decl. 1886·0 ° ′	Type of spectrum
D.M. + 44° 3877	21 31 42	44 51·9 N.	III.
249*a* Schjellerup	21 37 13	34 59·4 N.	IV.
μ Cephei	21 40 1	58 15·4 N.	III.
254 Schjellerup	21 40 41	2 44·4 S.	III.
258 Schjellerup	21 59 1	27 47·8 N.	III.
18 Cephei	22 0 26	62 33·8 N.	III.
D.M. + 56° 2821	22 34 8	56 12·2 N.	III.
β Pegasi	22 58 14	27 27·8 N.	III.

THE VOLCANIC ERUPTION IN NEW ZEALAND

FURTHER details have been received of the volcanic eruption in the Hot Lake district of New Zealand, which has been the scene of a terrible and unexpected catastrophe which occurred early on the morning of June 10. At Ohinemutu, on Lake Rotorua, the earth began to tremble at midnight. At ten minutes past 2 a.m. there was a heavy quake and a loud roaring noise which startled the inhabitants and caused them to flee from their houses. From this point it could be seen that Mount Tarawera, about fourteen miles distant, had suddenly become an active volcano, belching out fire and lava to a great height. At 4 a.m. a dense mass of ashes poured down, accompanied by suffocating smells. A large black cloud, which extended in a line from Mount Tarawera to the Pairoa Mountains, was filled with flame and electricity. The thunder-like roar from the crater, the sulphurous smells and constant quaking of the earth, caused many of the inhabitants to leave their homes and proceed to Tauranga, a distant township on the east coast. At 8 a.m. the aspect of affairs was as bad as it was all night, and hundreds of boiling springs had broken out around Lake Rotorua. At 11 a.m. the eruptions were going on continuously, and all the country down to Tauranga was in total darkness, with thick clouds of dust and sulphurous fumes in the air. At one o'clock the darkness had all cleared away and the principal centres of eruption had subsided.

At Lake Taupo, about forty miles to the south of Tarawera, the spectacle presented was most extraordinary. At 2 a.m. the outbreak was heralded by terrific reports, which resembled the roar of artillery, while a pillar of flame shooting hundreds of feet into the air was observed in the locality of the eruption. A great black cloud hung over this pillar, whilst flashes of electricity shot out from the cloud in every direction, shedding an unearthly bluish light. Loud reports, accompanied by heavy shocks of earthquake, followed in quick succession, and kept on until six o'clock, when the daylight and clouds of ashes rendered the sight invisible.

At Tauranga, forty-seven miles distant to the north-east, loud reports of heavy earthquakes began at 2.15 a.m., and very severe shocks were experienced at 3 a.m., while in the direction of the outbreak the country was illuminated for hours with flames and lightning. In the neighbourhood of Maketu, fifty miles to the east of the principal centre of eruption, atmospheric disturbances caused darkness till 10 a.m., and the shocks of earthquake were accompanied with strong lightning and earth currents, while at Hamilton, eighty miles to the west, the volcanic discharges are said to have resembled the firing of great guns at sea.

The devastation caused by the eruption is very widespread, and it is believed that all the natives round Rotomahana and Tarawera Lakes must have died. About a hundred Maoris are known to have perished. Mr. Haszard, the schoolmaster at Wairoa, and his four children and niece, and an English tourist named Bambridge are the only Europeans known to be killed. The country for fifty miles around the vicinity of the disturbance has been covered by the discharge of stones and ashes, and large craters have risen up. Mount Tarawera is elevated 300 feet higher than before. Lake Rotomahana has subsided, and has been transformed into an expanse of seething mud, and the renowned terraces are reported to be destroyed. Large areas are covered with volcanic dust and mud. During the disturbance the wind blew from the east, heavy snow fell on the ranges, and there was intense cold.

The wide area forming the scene of the eruption has been the chief centre of volcanic activity in New Zealand since the country has been known to Europeans, and in fact since the earliest period of Maori tradition. The region forms of itself a distinct volcanic zone remarkable for its picturesque hot lakes, boiling geysers, and numerous thermal springs. For many years it has been the resort of tourists from all parts of the world, and who reached it by way of Tauranga, a picturesque town on the east coast of the North Island, with a fine harbour opening into the Bay of Plenty. It is in this bay, about 30 miles from the mainland, that the first indication of volcanic activity presents itself in the form of Whakari, or White Island, a cone-shaped mountain which rises abruptly from the sea to an altitude of 860 feet. The crater, about 1½ miles in circumference, is in a condition of a very active *solfatara*, whose numerous geysers and boiling springs evolve at all times dense volumes of steam and sulphurous gases.

From Tauranga the traveller proceeds in a southerly direction through a fern-clad country interspersed with broad belts of primæval forest presenting the most luxuriant and varied vegetation. In a distance little short of 40 miles the land rises gradually to an altitude of 800 feet, when the great table-land of the Lake Region is reached. Here, in a depression which appears to have formed at some remote period the area of an immense lake-basin, is situated the township of Ohinemutu, where there are several good hotels and a small white population. Just beneath the township the blue surface of Lake Rotorua, with the picturesque Island of Mokoia in its centre, spreads itself out in a circle of nearly 25 miles. The area in the immediate vicinity of the lake, where the action of the thermal springs is most active, extends from Whakarewrewa on the one side to Te Koutu on the other, and inland to Tikitere and Ariki Kapa, celebrated for its big holes of black boiling mud. Hot springs occur on its southern shore, while still further to the east of it again are the warm lakes known as Rotorua and Rotoehu. The native settlement is situated on a long peninsula stretching out into the waters of Lake Rotorua. Every part of this strip of land is dotted and riddled with thermal springs, some of which shoot out of the ground from small apertures, while others assume the forms of large steaming pools. They are of all degrees of temperature from tepid heat to boiling-point. Here the *whares* or huts of the natives are clustered promiscuously about the springs, and in situations where a few inches below the surface the soil is sufficiently hot to cook an egg in a few minutes.

It is this region which may be said to contribute the first link in the chain of active thermal action, extending from Whakari in the Bay of Plenty, through the Lake Country, to the active volcano of Tongariro, in the centre of the island, a distance in a direct line of about 130 miles.

At a distance of about nine miles still southerly from Lake Rotorua, lies Lake Tarawera, with its cluster of minor lakes, which constitute the second and most important connection in the volcanic belt. It was here the recent volcanic disturbance first declared itself in the sudden activity of Mount Tarawera, an extinct volcanic cone which had remained quiescent since time immemorial.

No place in the world could boast of scenery so unique and thermal phenomena so marvellous as could Tarawera and its surroundings. It was reached from Tarawera by a delightful route fringed by fern-clad mountains, and through the Sikitapu Forest one of the grandest gardens of primæval vegetation in New Zealand, but which is now uprooted by the force of the subterranean devastation. At the southern exit of the forest the traveller was charmed by Sikitapu, the Blue Lake, and Rotokakahi, the Green Lake, whose calm picturesque beauty formed one of the grandest sights of this singularly gifted region. A few yards from this point nestled the native settlement of Wairoa, now covered with 10 feet of ashes. Here were two hotels for the accommodation of tourists, who came from places far and wide to visit the wonders of the Terraces. From time out of mind it had been one of the principal homes of the great Arara tribe, who claim to be the pioneers of the race in New Zealand.

Down a wild gorge from Waira Lake Tarawera lies embosomed in a circle of tall forest-clad mountains, whose pointed peaks and serrated ridges betoken at once their Plutonic origin, while on the southern shore of the Lake rises Mount Tarawera, in the form of a colossal truncated cone, with pointed peaks like a spiked crown. It was out of this giant mountain *tapu*, and sacred in Maori song and legend, that the recent subterranean fires first shot forth, enveloping the whole mountain in a sheet of flame.

A glance at this mountain and the surrounding region was sufficient to show that at some remote period it must have been —as now—the chief centre of a widely-extended volcanic action. The mountain itself formed one of the principal volcanic cones to be found dotted over the country. A range of volcanic hills sloped down on its western side to Lake Rotomahana, which was connected with Lake Tarawera by a small warm stream known as Te Ariki. Before the eruption occurred the shores of the former lake formed the principal point of thermal activity in the district, and there can be little doubt that beneath its surface the forces which culminated in the outbreak of Mount Tarawera were evolved.

Lake Rotomahana, now said to be nothing more than a hole of seething mud and vaporous gases, formed in reality the wonderland of the region. Like Lake Tarawera, it was situated at an elevation of a little over 1000 feet above the level of the sea. It was one of the smallest of the group of lakes, being about a mile long by a quarter of a mile wide. It was, however, grandly picturesque, not only by reason of its unequalled features presented by the terraces, but likewise on account of its steaming shores with their countless hot springs, boiling geysers, steaming cauldrons, and seething mud-pools, as well as by the bold, rugged scenery which surrounded it on every side. The name Rotomahana in the native language means literally "hot lake." The mean temperature of the water was about 80° F., while in the vicinity of the hot springs it rose frequently to 212° F.

It was on either shore of this lake that the marvellous terraces now unfortunately reported to be destroyed were situated. The largest of these singular formations was Te Tarata, or the White Terrace, the outline of which assumed a semicircular form and spread out at its base as it sloped gently down to the margin of the lake; the broad, flat, rounded steps of pure white silica rose tier above tier white and smooth as Parian marble and above them terrace after terrace mounted upwards, rounded and semicircular in form. All were formed out of a delicate tracery of silica, which appeared like lacework congealed into alabaster of the purest hue; crystal pools shaped as if to resemble the form of shells and leaves, and filled to their brims with water blue and shining as liquid turquoise charmed the eye, while around the edges bright crystals of silica formed incrustations which made them appear as if set with a margin of miniature pearls. At the summit of the terrace was a crater of 200 feet in diameter filled to overflowing with brilliant transparent water in the form of a boiling fountain, from which clouds of steam floated constantly upward. This boiling spring formed an intermittent geyser, which during its active intervals threw up a column of water to a height of over 100 feet. The crater, however, was always overflowing, and the water, which was highly charged with silica, had by a gradual process of deposition, extending probably over a vast period, formed the present system of terraces. The temperature of the water varied from boiling point to 70° F. at the foot of the terrace, the summit of which was over 80 feet above the level of the lake.

Immediately at the back of the White Terrace and bordering the lake was a rocky desolate gorge seamed and furrowed in every direction with streams of hot water, while jets of hissing steam bursting from its sides marked the sites of subterranean fires. The high hills on each side of the gorge rose up in quaint fantastic shape, and their rugged sides composed of shattered volcanic rock sent forth water and jets of steam from a thousand fissures. Here boiling geysers emitting clouds of steam lashed their hot waves about and foamed with a furious sound in rock-bound basins, while scattered over the greater portion of this fiery wilderness were innumerable fumaroles all hard at work shooting out steam and vomiting black streams of liquid mud. Some of these were round, some flat, and others cup-shaped, while not a few assumed the form of miniature volcanoes.

It was opposite to this spot on the further shore of the lake, that Te Otukapurangi, or the "Fountain of the Clouded Sky" of the Maoris, or the Pink Terrace, rose from the water of the lake to an altitude of nearly 100 feet. Here the deposits of silica assumed the same general formation, and each terrace of steps was gracefully and marvellously shaped with rounded edges which swept about in waving curves. The various buttress-like masses which supported the fringed edges of the terraces bent over and formed miniature grottoes resplendent with festoons of pink-tinted silica and rose-coloured stalactites which appeared to have been woven together by nature into an intricate network and then crystallised into their present shape. Here the successive deposits or layers of silica-rock did not assume, like those of Te Tarata, a wonderful combination of delicate lacework around the edges of the terraces, but the siliceous laminations appeared even thinner, and reminded one of the corrugated surface of pink satin rep. It was, however, the variegated tints of this wondrous structure which rendered it even more remarkable than the gracefully symmetrical proportions of its incomparable design. As the blue-tinted water came rippling and falling from terrace to terrace in miniature cascades, Te Otukapurangi looked radiant in its sparkling mantle of delicate pink, and as the golden rays of the sun shot far and wide, it changed with every shade of light, with brilliant hues of pink, amber, carmine, and yellow, which shone with a dazzling and metallic lustre as they flashed and palpitated as it were in the warm glowing air.

At the summit of the terrace was a circular platform, in the centre of which was a steaming cauldron formed by an alabaster-like basin about 100 feet in diameter. Here the deep dark-blue water within a few degrees of boiling-point lay without a ripple upon its surface, and shone with the brilliancy of transparent crystal, while beneath the siliceous deposits, which encrusted the sides of the crater, assumed all the varied designs of a coral grove tinted in glowing colours of yellow, blue, and pink.

From Lake Rotomahana the recent volcanic eruption extended to the Pairoa Mountains, which attain to an altitude of 1000 feet, and which, when visited by Mr. Kerry-Nicholls, were hot, and quaking with internal fires, boiling mud pools, and coiling jets of steam that burst with a hissing sound from the deeply-scarred hills. The base of this range, where the volcanic action was greatest, was formed of a burnt fiery-looking earth, broken here and there into enormous fissures, and dotted about with boiling pools and deep holes of hot seething mud, while clouds of vapoury steam burst forth from the highest peaks.

Following up the line of thermal activity across the island, as yet not known to be affected by the recent outbreak, hot springs and geysers are found at Orakeikorako on the banks of the Waikato and in various places along the whole valley of the rivers, and notably at Wairakei, where the thermal activity is both widespread and extraordinary in its variety. At Taupo, the great central lake of the island, geysers and other phenomena of the kind exist on its northern shores. From this point further across the lake the hot springs and geysers of Tokanu occur, while a short distance beyond rises the cone-shaped form of Tongariro, at an altitude of 7000 feet, the two craters which are in a state of very active *solfatara* constantly emit vast volumes of steam. Five miles to the south of the latter mountain rises the colossal form of Mount Ruapehu, which, with a base of over sixty miles, rises to an altitude of 6000 feet to the region of perpetual snow. This mountain, which was at one time the chief centre of volcanic activity of the north island, has been extinct from time immemorial, but it is reported that during the recent eruption steam was seen to issue from the crater. It is the highest point of the north island, and was ascended by Mr. Kerry-Nicholls and his interpreter, Mr. Turner, in 1883.

SCIENCE IN NEW SOUTH WALES

IN his Annual Address (on May 5) to the Royal Society of New South Wales, the President, Prof. Liversidge, referred to the death of Prof. Smith, the former President of the Society, and to the eminent services which he had rendered to the cause of science and of education in New South Wales, and also to other members of the Society who died during the past year. The President then expressed regret that the number of original papers contributed to the Society is so small. "It is not," he said, "from lack of subjects, for there are many questions which require investigation, but rather from the lack of competent investigators who can spare the necessary time. Up to the present but little original work has been done in working out the chemistry of the mineral and vegetable products, and but very little in many branches of biology. The descriptions, catalogues, lists, &c., of the flora and fauna, are making fair progress, but still very little has been published relating to the development and life-history of the fauna of Australia, even of forms of life peculiar to that part of the world. In matters of natural history, geology, and allied subjects it is apparent to every one that the materials for original work are in New South Wales abundant, and a considerable amount of very valuable work is being done in this direction by the Linnean Society of New South Wales, but the amount waiting to be done is far more than they can cope with at present. The Society, by offering a medal and a money prize, has done what it can to stimulate research; but the amount at its disposal is small. So many subjects if thoroughly worked out would be of economic value to the colony—such as the chemistry of Australian gums and resins, the tin deposits, iron ores, and silver ores of New South Wales—that the Government might with propriety assist the Society in undertaking these researches. Wealthy colonists might also, with advantage to the State and credit to themselves, encourage such original investigation." Speaking of biological work, the President said that one of the few facilities for scientific work possessed in Sydney, and which the Society assisted in founding, viz. the biological laboratory at Watson's Bay, has been closed, the Government having taken the house and grounds for defence purposes. The trustees will doubtless receive the cost of the buildings, and with this as a nucleus a fresh start can be made. It would be a great pity to allow such an undertaking to drop, especially as there is such an unlimited field for marine biological work in Australia. In regard to scientific education in the colony, Prof. Liversidge said that notwithstanding the liberality of Parliament and the receipt of private endowments for improved instruction in science, many of the arrangements for this purpose of the Sydney University are of a very meagre and imperfect character. The Board of Technical Education is now doing good work in spreading elementary, scientific, and technical education over the colony by means of science classes and itinerant lecturers. The necessity of scientific education is also being recognised; there is a motion before the Legislative Assembly to place the sum of 10,000*l.* upon the estimates for the establishment of schools of mines in the various mining centres, while another motion to be brought proposes to make provision for the creation and endowment of twenty scholarships of the value of 200*l.* per annum, each tenable for three years, at the Sydney University. The President then referred to Prof. Huxley's remarks in his anniversary address to the Royal Society on scientific federation. Prof Huxley said:—"I have often ventured to dream that the Royal Society might associate itself in some special way with all English-speaking men of science; that it might recognise their work in other ways than by the rare opportunities at present offered by election to our foreign fellowship, while they must needs be deprived of part of its privileges." On this Prof. Liversidge remarks that though every one will agree as to the desirability of having closer bonds of union between the Royal Society and the men of science who are scattered over the wide areas of English-speaking countries, it does not appear easy to suggest a method of bringing it about. Good work in the Colonies, at any rate at present, is rarely overlooked by the Council of the Royal Society. Prof. Liversidge concluded his interesting address by suggesting a federation or union of the members of the various scientific societies in Australia, Tasmania, and New Zealand into an Australasian Association for the Advancement of Science, on the lines of the British Association, with a view to holding the first general meeting in Sydney on the hundredth anniversary of the founding of the colony. A meeting of the kind during the centennial year would offer a unique opportunity for the exchange of ideas and information, and it would not only have an immediate and beneficial effect, but would permanently raise the high-water mark of thought in all the colonies, especially in connection with scientific matters. It would be an opportunity to correlate and correct all the scattered and fragmentary geological maps and memoirs relating to the various colonies, and to adopt a uniform system of nomenclature, colouring, &c., for all Australasian geological maps. It would, pursued the President, be beneficial if botanists were to prepare and revise the census of plants for each colony, especially to show their distribution, and similar questions could be discussed by zoologists for land and marine organisms.

ICE MOVEMENTS IN HUDSON'S BAY[1]

IN my report last year I described the ice as consisting of three kinds, viz., icebergs, heavy arctic ice and ordinary field ice. The icebergs are stated to have come from Fox Channel. This conclusion was based on the report from No. 3 station made on the homeward voyage of the *Neptune*, that the icebergs passed the bluff from west towards east. This report was made on the strength of the few observations which the party had been able to make in the interval between the two calls of the *Neptune* at the inlet. Further and more perfect observations show conclusively that the current sets in the opposite direction and that the icebergs move from east to west. If further proof of the existence of this set were necessary, we have it in the drift of the *Alert* when fast in the ice off Ashe Inlet and invariably carried to the westward.

In considering the question of the sources from which the ice affecting Hudson's Straits navigation comes, we must first begin with the east Greenland ice. All those who have made the voyage from any port in Europe to Hudson's Straits seem to agree in the statement that Cape Farewell must not be approached nearer than seventy miles in order to keep clear of the east Greenland ice which sweeps round the cape in an almost ceaseless stream, after rounding which it turns to the northward, and passes up the south-west shore of Greenland, nearly as high as Gothaab, then turns over to the west side of Davis' Straits, and joining the stream of Davis' Straits ice runs south with the arctic current. The limits of the east Greenland ice field, when rounding Cape Farewell, vary greatly; in some years, it moves as far south as the parallel of 58° N. This ice field can be, and is of course always avoided, the rule in making the passage being to keep to the south of 58° N. till in longtitude 58° W., on which meridian the northing should be made.

The stream of Davis' Straits ice flows right across the entrance to Hudson's Straits, and varies in width with the season of the year. The first information which I have of it was derived from conversation with Captain Watson, of the whaling barque *Maude* of Dundee, owned by Captain Adams. Captain Watson had been for many years engaged in the Davis' Straits whale fishing, and for the last few years has commanded his present vessel. Their usual routine is to leave Dundee in March, and they arrive off the edge of Davis' Straits ice in the early part of April, cruising off the edge of the ice between latitudes 58° N. and 63° N. Captain Watson told me, that he made the ice in April of this year about 58° N. and 120 miles off the Labrador coast, and up to the date of our meeting with him, June 13, he had not been able to get nearer to Resolution Island than thirty-five miles, and as the average southerly set of the current is about twenty miles per day, this stream of ice must have been flowing uninterruptedly up to June 15, the date on which the *Alert* took the pack. An examination of the records of the stations at Port Burwell and Nachvak Bay shows that at Port Burwell the ice cleared out of the Straits on April 9. They remained clear up to the 14th, when the ice came in sight again, and was present almost constantly thereafter until its final disappearance in August. At Nachvak the ice swung on and off the shore with the winds and tide, but though sometimes out of sight from the ordinary observation point, it was always seen upon going to a higher elevation. It is therefore certain that during the months of May, June, and July, large fields of ice were present in the entrance of the Straits, and the question remains, at what date was this ice in such a condition as to permit the passage of vessels strengthened for meeting the ice, but which could be used as freight steamers. For in all questions as to feasibility of the navigation I am not considering the date at which one of the Dundee whaling or Newfoundland sealing steamers could be forced through, but when a strongly built iron steamer, sheathed and otherwise strengthened, could make the passage.

On June 15, when we went into the ice, it was certainly impenetrable by any vessel of the class referred to, and though the ice would slacken at the turn of every tide, and sometimes run abroad so that it would have been possible to work the ship to the westward, distances varying from two to five miles at each of these slack times, I only tried to hold my own, generally under canvas; as apart from any question of the injury which the ship had received, I deemed it more desirable to watch the ice at the entrance of the Straits than to force the ship through, when I could only have made at the most ten to twenty miles a day. I am of opinion that the Straits were passable at the eastern entrance about the date that we returned to St. John's for repairs, viz., July 5, but any ship going in at this date would still have been subject to these delays, but might have made from twenty-five to forty miles a day.

Proceeding westward, from this date, July 5, the observations at Ashe Inlet and Stupart's Bay show that on the north side of the Straits, and from eighteen to twenty miles out, the ice was present almost continuously, much as we found it in August; some of the sheets of enormous extent and of great thickness. Many of these were, in August, over half a mile long, and some which we measured were from twenty to thirty feet in thickness. In the middle of July, Mr. Ashe reports that open water is visible beyond the ice, and Mr. Stupart, fog-banks and water sky frequently to the north. The two stations at the western end of the Straits also report that in the middle of July the ice was loose and drifting with the tide. Everything goes to show that though there would have been very frequent delays still it would have been possible for a steamship to have got through the Straits by July 15 or 20.

Ice would have been met with again, doubtless, in the bay, but I do not think there would have been any serious delay in reaching either Churchill or York Factory.

Stations on shore for the purpose of watching the movements of the ice, though undoubtedly the best system which we can adopt, cannot tell us with any degree of certainty how soon a vessel might be able to push her way through the Straits, but they do tell when it is sufficiently run abroad, or

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[1] From the Report of the second Hudson's Bay Expedition under the command of Lieut. A. R. Gordon, R.N., 1885.

when a sufficient amount of open water appears, to make the passage a reasonable certainty, and the date for this year I place at from July 5 to 15, as it is more than likely that a ship could have got through the Straits in ten days. The ice is, moreover, so sensitive to wind that even if telegraph stations were so placed as to be able to convey to ships news regarding the position of the ice ahead, long before the vessel arrived at the place the condition of affairs might, and probably would, be totally changed.

As to the closing of navigation in 1884, Mr. Laperrière reports, at Cape Digges, that on October 25 the ice was solid in every direction, and at Nottingham Island a similar entry is made on the 27th. A distinction must be made between the closing of navigation by the formation of young ice, and the presence of a large field of heavy old ice which is cemented together by the formation of young ice between the pans. In the first case any ordinarily powerful steamer could go through without risk, but in the second case the most powerful of the whaling or sealing steamers would be helpless. The western end of the Straits is always subject to incursions of this heavy ice, from Fox Channel, and especially so in the months of September and October, when strong north-easterly and north-westerly gales are frequent, and we have now evidence that in both seasons, 1884 and 1885, this heavy ice came down in October.

As to the length of season for practical navigation, if we regard the presence of field ice as the only barrier, the information which we have got would point to the months of July, August, September, and October as being the months in which the Straits are passable. As a rule, in July there will be delays, but to vessels strengthened and sheathed there would be no danger in making the passage.

All the inhabitants of the Labrador, the Straits, and the Bay, spoken to on the subject, agreed in stating that the ice movements this year were much later than the average; at Fort Churchill the season was fully a month late, and on the Labrador three weeks, so that I think it will be found that on the average four months will be the length of the season for practical navigation by steam vessels which would be freight-carriers. There have been, I am informed, seasons when the Straits were clear of ice in the month of June, but they are, according to the logs of the Hudson's Bay ships, quite exceptional. Captain Hawes spoke of such being the case only once in his experience of fourteen years, and the dates which I have seen of the arrival of the Hudson's Bay vessels at their ports of destination show no arrival earlier than August.

THE TRANSCASPIAN FAUNA

We notice in one of the last issues of the *Bulletin* of the Moscow Society of Naturalists (1885, No. 2) a most valuable paper, by M. Zaroudnoi, on the birds of the Transcaspian region. His list contains an enumeration of 184 species, well determined on 600 specimens—doubts remaining only with regard to a very few species. The author distinguishes in the region the following chief zoological sub-regions:—(1) The Kara-kum desert, having a pretty well furnished flora, notwithstanding its immense sandy plains and salt clays. The Tamarix forests, now mostly destroyed, are well peopled with the *Atraphornis aralensis*, as also with a few *Podoces* (*Panderi?*) and *Passer* (*ammodendri?*), which make their nests further north in the *saksaul* forests. The *Houbara quennii*, Gray, is rare. The reptiles are represented by the *Phrynocephalus interscapularis* and *helioscopus*, *Agama sanguinolenta*, *Testudo*, *Naja oxiana*, Eichwald; the *Varanus sciucus* extends much further south into the Akhal-Tekke plain, and even to the Kopet-dagh Mountains. (2) The Akhal-Tekke oasis, striking by the monotony of its landscape, diversified only by the gardens of the Tekkes, which remain green even during the hottest part of the summer, when all vegetation is scorched up by the sun. In the plain only the Tamarix, a few willows on the banks of the rivulets, and the dark-green bushes of the capers, adorned with pretty flowers, are to be seen. The great areas covered with bushes of *Alchagi camelorum* and wormwood increase the monotony of the landscape. Pretty *Julodis variolarius*, *eufraticus*, and sometimes *globicollis* are often found flying around these bushes; in July the *Fisheria baetica*, Ramb., several Irises, as also *Empus pennicornis*, Pall., several kinds of *Ateuchus* and *Copris*, and numerous species of *Melanozomatæ* are met with. The stone-chatters (traquets) and larks are so numerous as to become troublesome. The *Phrynocephalus helioscopus* and *Agama sanguinolenta* fly at the approach of man. From time to time a *dscheiran*, or a fox, may be perceived. The nights are sultry and hot, and one hears the shrivelling of the *Grillus cerisyi*, Serv., and *G. capensis*, Fabr., the barking of the jackals, and the cries of *Caprimulgus arenicolor*, Sev. The banks of the few rivers, covered with brush and reed-grass, are the refuge of the wild cat and the *Lagomys*. The high summer temperature of the oasis is well known: 40° Cels. in the shade being not uncommon; and M. Zaroudnoi is inclined to ascribe to the great heat the intensity of the moulting of birds. The lark loses so much of its feathers that the body remains in many parts quite naked; with the stone-chatters only the base of the feathers remains on their heads. Most of the birds met with in the oasis during the summer belong to the Aral-Caspian fauna, the others come from the mountains; these last have followed the courses of the rivers and have taken possession of the Akhal-Tekke gardens; such are the *Salicipasser montanus*, *Passer indicus*, *Sylvia mystacea*, *Butalis grisola*, a great number of *Salicicariæ*, and several others. Some, like the griffons, the ravens, the *Cypselus apus*, the *Chelidon urbica*, the *Merops apiaster*, inhabit the mountains, and descend to the plain only for hunting. The *Galerita magna*, *Calandrella pispoleta*, and *Saxicola isabellina*, may be considered as representatives of the Akhal-Tekke fauna owing to their considerable numbers. (3) The mountain-region is much more interesting, especially when the traveller reaches the upper valleys covered with forests, where the vines grow wild. Wild cats and jackals are the usual inhabitants of these valleys; but the *Cynailurus jubatus* and the *Leopardus pardus* are rare; *L. irbis* is never met with in the region. *Hyæna striata* is occasionally met with. *Ellobis talpinus*, several *Erinaceus* and *Platycercomys*, as also *Histrix hirsutirostrix* are common. The dreadful *Vipera eufratica* is a source of continual danger during the grape-harvest. *Eremias velox* and *Agama sanguinolenta* are worthy of notice. As to the birds, we must merely refer to the list of M. Zaroudnoi, where notes as to their distribution are given in French. The zoological determinations have been revised by M. Menzbier.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, May 27.—"Researches in Stellar Photography." By the Rev. Prof. Pritchard, F.R.S.

The objects of these researches are:—(1) To ascertain, if possible, by means of definite and accurate measurement, as distinguished from impressions and estimates, what is the relation between the diameter of a star-disk impressed on a photographic plate with a given exposure, and its photometric magnitude, instrumentally determined. With this view, five plates of the Pleiades were taken with different exposures, on different nights. The diameters of the star-disks on each of the plates were then measured with a double-image micrometer, checked by measurement also with the macro-micrometer in the Oxford University Observatory. Curves were then drawn for each of the plates, taking the magnitudes as given in the "Uranometria Nova Oxoniensis" as abscissæ, and the measured diameters as ordinates. The result was a satisfactory coincidence in the case of all the plates, leading, when treated in the usual manner, to the final result—

$$D - D' = \delta \left\{ \log M' - \log M \right\} \qquad . \quad . \quad . \qquad (1)$$

where D, D' are the measured diameters of any two stars on the plate, and M, M' the corresponding photometric magnitudes; δ being a definite constant depending on the physical circumstances of the particular plate.

It was observable that, out of twenty-eight stars examined, three stood out from the rest, indicating, as might have been expected, some peculiarity in the spectra of these stars. In the memoir itself the tabular relations of all the measures are exhibited. The similarity of the symbolical form above to the relations existing between "magnitude" and intensity of light is obvious and interesting.

(2) Another branch of the inquiry is still more important, and it is this. Seeing that in the modern use of the dry plates the times of exposure are so considerable, and the processes of development and drying, &c., so suspiciously dangerous to the stability of the films, it becomes a matter of great importance to ascertain

whether the photographic plate remains an absolutely accurate picture of the actual relative positions of the stars in the sky itself, and, moreover, whether these are measurable with that extreme degree of precision which is attainable with the best instrumental means. To ascertain this, the same plates for a portion of the Pleiades were taken which gave rise to the formula already obtained. The distances of some twenty-five of the stars from Alcyone were measured on each of these plates, the number of repetitions of the measures being made the same as those adopted by Bessel in his measures of the same distances with his heliometer. The resulting accordances of these individual measures on each of the plates was very satisfactory, and a trifle better than the accordances in the case of Bessel's measures; and the accordance of each of the means of the distances of each of the stars from Alcyone on each plate was at least quite equal to the results obtained with the heliometer. The average deviations from the mean for all the measures was, in the case of the photographic plates, 0″·24, and, of the heliometer measures, 0″·29. These satisfactory accordances of the resulting measures on each of the plates (corrected for refraction, and where necessary for aberration), afford a sure indication of the reality of the pictures, as well as of their accurate measurability.

An interesting circumstance occurred in the course of the work. On one of the plates the distances of three stars from Alcyone exhibited a slight discordance of from 0″·75 to 1″·5, when compared with those stars on the other plates. These three stars all occupied a small area on the plate; no discordances occurred on this plate with respect to any of the other stars. Here is an indication of a slight disturbance of the film on one small portion of the plate, but on no other portion. Hence the necessity of the precaution of taking at least three plates for the purpose of security of measurement. The plates were exposed variously for about 8 to 12 minutes in the focal plane of the de la Rue reflector of 13 inches aperture.

(3) A few stars were examined on the same plate with different exposures, varying from 1 second to 120, with the view of ascertaining, if possible, the relation between the areas of the impressed star-disks and their time of exposure. As far as at present appears, these areas vary as the square root of the time. This result differs widely from that obtained by Bond in 1858. That astronomer considered that these areas varied directly as the time; the investigation, however, is not yet complete, and will be resumed at Oxford. It is well known that these photographic disks are not sharply and definitely cut circles on the negative plate, when examined with the higher powers of the microscope, such as 100 and beyond; but they are fringed with a number of discreet black dots extending to some distance beyond the hard photographic images. Nevertheless, these images, when printed in the form of position, lose this fringe, and present the appearance of well-defined sharply-cut circles; the light appears to have penetrated through the interstices of the discrete fringe, and leaves a very definite outline. Encouraged by these results of the measurements of the stars from Alcyone, I propose to test this photographic method still further by applying it, not without hope of success, to the question of stellar parallax.

These measures are now well advanced, and afford good hope of success.

Chemical Society, June 17.—Dr. Hugo Müller, F.R.S., President, in the chair.—The following were elected Fellows of the Society:—Thomas Akitt, James Blake, M.D., Alfred Chaston, A. W. H Chapman, Augusto Cæsar Diojo, Charles A. R. Jowitt, Charles Alexander Kohn, John Temple Leow, William Ray, Joseph Price Remington, William Richards, Forbes Rickard, William Saunders, Charles A. Smith.—The following papers were read:—The electrolysis of aqueous solutions of sulphuric acid, with special reference to the forms of oxygen obtained, by Prof. H. McLeod, F.R.S.—Essential oils (Part III.): their specific refractive and dispersive power, by Dr. J. H. Gladstone, F.R.S.—The formation and destruction of nitrates and nitrites in artificial solutions and in river and well waters, by J. M. H. Munro, D.Sc.—Water of crystallisation, by W. W. J. Nicol, M.A., D.Sc., F.R.S.E.—A method of investigating the constitution of azo-, diazo-, and analogous compounds, by R. Meldola, F.R.S., and F. W. Streatfeild.—The estimation of free oxygen in water, by Miss K. I. Williams and Prof. W. Ramsay.—Note as to the existence of an allotropic modification of nitrogen, by Miss K. I. Williams and Prof. Ramsay.—The presence of a reducing agent, probably hydrogen peroxide, in natural water, by Prof. Ramsay.—Evaporation and dissociation (Part IV.); a study of the thermal properties of acetic acid, by W. Ramsay, Ph.D., and Sydney Young, D.Sc.—Note on the vapour-densities of chloral ethylalcoholate, by William Ramsay, Ph.D., and Sydney Young, D.Sc.—The nature of liquids as shown by a study of the thermal properties of stable and of dissociable bodies, by William Ramsay, Ph.D., and Sydney Young, D.Sc.—The electromotive forces developed during the combination of cadmium and iodine in presence of water, by A. P. Laurie, B.A., B.Sc.—Detection and estimation of iodine, bromine, and chlorine, by M. Dechan.—The analysis of alloys and minerals containing the heavy metals, selenium, tellurium, &c., by Thomas Bayley.

Entomological Society, July 7.—Mr. J. Jenner Weir, F.L.S., Vice-President, in the chair.—Mr. S. H. Scudder, of Cambridge, Mass., U.S., was elected a Foreign Member of the Society.—The Rev. H. S. Gorham exhibited specimens of *Eucnemis capucina*, Ahr, a species new to Britain, discovered in June last in an old beech tree in the New Forest. He also exhibited specimens of *Cassida chloris*.—Dr. Sharp exhibited larvæ of *Meloë*, and read notes on their habits, and Mr. Saunders exhibited a specimen of *Halictus* infested with about thirty *Meloë* larvæ. Mr. Billups remarked that he had recently found forty-seven larvæ of *Meloë* on the body of a species of *Eucera*. Dr. Sharp said that he was of opinion that the operations of these larvæ were not the result of instinct, but were more like reflex actions: the instant the larvæ touched a suitable surface they clung to it. The discussion was continued by Prof. Riley, who disagreed with Dr. Sharp, and believed these larvæ were guided by instinct, as they showed a decided preference for particular hosts.—Mr. Jenner Weir exhibited a male of *Lycæna bellargus* and a female of *L. icarus*, which had been captured *in copulâ* by Mr. Hillman, and shown to the exhibitor at the time of capture. Mr. Weir also exhibited some specimens of *Lycæna* which he believed to be hybrids between *Lycæna bellargus* and *L. icarus*; and he further exhibited, on behalf of Mr. Jenner, four specimens of *Phosphænus hemipterus*, taken at Lewes.—The Rev. W. W. Fowler exhibited two specimens of *Chrysomela cerealis*, lately taken by Dr. Ellis on Snowdon; and also two specimens of *Actocharis Readingii*, found at Falmouth by Mr. J. J. Walker.—Mr. E. B. Poulton called attention to the fact that the larvæ of some Lepidoptera, if fed in captivity on an unusual food-plant, subsequently refused to eat their ordinary food-plant. He stated that he had observed this with the larvæ of *Pygæra bucephala* and *Smerinthus ocellatus*. Mr. Stainton, Mr. Fowler, and Mr. Goss made some remarks on the subject.—Mr. Elisha exhibited a series of bred specimens of *Geometra smaragdaria*.—M. Alfred Wailly exhibited a long series of silk-producing moths, including some remarkable hybrids between *P. cecropia* and *P. ceanothi*; and Prof. Riley and Mr. Weir made some observations on these hybrids.—Dr. Sharp read a paper on *Eucnemis capucina* (Ahr.) and its larva.—Mr. Dunning read a report on the subject of the importation of humble-bees into New Zealand, from which it appeared that the efforts of Mr. Nottidge, of Ashford, and the Canterbury (N.Z.) Acclimatisation Society had been successful, and that the long wanted clover-fertiliser had at length been established in New Zealand.—M. Peringuey communicated notes on some Coleopterous insects of the family *Paussidæ*.—Mr. J. B. Bridgman communicated additions to the Rev. T. A. Marshall's Catalogue of British Ichneumonidæ.—Prof. Riley read notes on the phytophagic habit, and on alternation of generation, in the genus *Isosoma*. In this paper Prof. Riley described, from direct observation, the phytophagic habit in two species of the genus. He also established the existence of alternation of generation.

EDINBURGH

Royal Society, July 5.—The Hon. Lord Maclaren, Vice-President, in the chair.—In a paper on the electrical resistance of nickel at high temperatures, Prof. C. G. Knott, of Tokio University, gave an account of experiments on certain nickel wires, in which the temperature was carried to a fairly bright red head. The resistance at different temperatures was compared with the resistance of a platinum wire at the same temperatures; and, by the substitution of other metals for the nickel, further comparisons were established. Nickel, platinum, palladium, and iron were thus studied; and the general conclusions were as follows:—(1) The rate of growth of the resistance of a given nickel wire with temperature is greater, on the average, than the corresponding quantity for platinum or palladium, and less than that for iron. (2) The "logarithmic rate"—that is, the rate of change per unit rise of temperature of unit resistance at any temperature—falls off more slowly for nickel as the temperature rises to 200° C. than for platinum or palladium. (3) At about 200° C. the rate of resistance growth for nickel increases markedly, and continues practically steady, till about 320° C., when a sudden decrease occurs, and thereafter the resistance steadily increases at this diminished rate. In other words, between the limits of temperature specified, the slope of the resistance curve is much steeper than for any other. The same peculiarity is probably possessed by iron between the temperatures of a dull red and a bright red heat. (4) The peculiarity occurs (in each case) between the limits of temperature within which the striking thermo-electric peculiarity discovered by Tait also occurs. This peculiarity, which is most briefly described as an abrupt change in the sign of the Thomson effect, is not known to be possessed by any other metal. (5) There is thus a strong presumption that the Thomson effect in metals has a close connection with the mutual relations of resistance and temperature—at any rate in metals in which the Thomson effect is proportional to the absolute temperature (according to Tait's theory) the "logarithmic rate" of change of resistance seems to be very approximately inversely as the absolute temperature. In nickel and iron, in which the law of the Thomson effect is peculiar, such a simple relation between resistance and temperature does not hold.—Prof. Tait discussed the effect of external forces on a system of colliding spheres. He gave a proof, much more simple than Maxwell's, of the fact that gravity has no effect in altering a uniform distribution of temperature throughout a vertical gaseous column. His proof is founded on the assumption that, in a horizontal layer of gas which has arrived at a steady state, all particles passing across the upper surface do so on the whole as if they had freely passed through the layer.—Dr. John Murray read a paper by Dr. H. B. Guppy on the mode of formation of the coral reefs of the Solomon Islands. In this paper the typical reefs were described with the various corals growing on them. In places exposed to the full sweep of the trade-winds the corals do not grow higher than to about 7 or 10 feet from the surface. In sheltered places they are found at a depth of from 4 to 5 feet. Dr. Guppy believes that the reefs never rise to the surface without upheaval. He gives a theory of the construction of barrier reefs, which corresponds to that formerly given by Le Comte to explain the reefs of Florida.—Mr. J. T. Cunningham, of the Scottish Marine Station, read a paper on the eggs and early stages of some teleosteans, and also a paper on the reproductive organs of *Bdellostoma*, and a teleostean egg from the West Coast of Africa.—Mr. Patrick Geddes gave a synthetic outline of the history of biology, and also read a paper on the theory of growth, reproduction, heredity, and sex.

SYDNEY

Linnean Society of New South Wales, May 26.—Prof. W. J. Stephens, M.A., F.G.S., in the chair.—The following papers were read:—Notes on some Australian Tertiary fossils, by Capt. F. W. Hutton. In this paper, which is based on the examination of a fine collection of Australian Tertiary fossils recently sent to the Canterbury Museum by Prof. Tate of Adelaide, Capt. Hutton enumerates seventeen species of molluscs and echinoderms which are common to the Tertiary strata both of Australia and New Zealand, and deals with their synonymy.—On some further evidences of glaciation in the Australian Alps, by James Stirling, F.L.S., communicated by C. S. Wilkinson, F.G.S. After reviewing what has been written on the subject of glacial action in Australia, the author adduces fresh evidence in favour of such action, obtained by himself and Dr. Lendenfeld during a recent visit to Mount Bogong, the highest mountain in Victoria, where erratics, perched blocks, smoothed surfaces, and old moraines were met with.—Jottings from the Biological Laboratory, Sydney University, by W. A. Haswell, M.A.: (No. 7) On a method of cutting sections of delicate vegetable structures; (No. 8) on the vocal organs of the Cicada.—Mount Wilson and its ferns, by P. N. Trebeck. Mr. Trebeck describes the position, geology, soil, and vegetation generally of Mount Wilson, and gives details of 15 genera of ferns, including 38 species, which were growing there in the greatest luxuriance from the very summit to a considerable distance down the slopes and gullies of the mountain.—List of the Rhizopoda of New South Wales, by Thomas Whitelegge. The list contains 24 species, with exact localities, and notes on collecting, preserving, and mounting Rhizopods. The species are mostly identical with those found in Europe, America, and India. Amongst those of interest the following may be mentioned:—*Arcella dentata*, Ehr., *Pelomyxa palustris*, Greeff, *Raphidiophrys elegans*, Hert. and Less., *Clathrulina elegans*, Ceinkowski, and *Biomyxa vagans*, Leidy.

PARIS

Academy of Sciences, July 19.—M. Jurien de la Gravière, President, in the chair.—Remarks accompanying the presentation of M. de Saint-Venant's important manuscript memoir on "the resistance of fluids," by M. Boussinesq. This unpublished work, begun in 1847, and not completed till the year 1885, a short time before the author's death, embodies historical, physical, and practical considerations regarding the problem of the mutual dynamic action of a fluid and a solid, especially in the state of permanence supposed to be acquired by their movements. It comprises three parts, the first dealing with the researches of previous physicists on the impulse of fluids in motion on solid bodies encountered by them; the second showing theoretically that this impulse is connected exclusively with the "imperfection of the fluid," that is, the development of friction, which to be surmounted requires a higher pressure on the upper than on the lower surface of the submerged body; the third containing a practical calculation of the impulse experienced by a body in any indefinite fluid current.—On the displacement of ammonia by other bases, and on its quantitative analysis, by MM. Berthelot and André. It is shown that in the presence of soda the double salts yield their ammonia far less readily than the sal ammoniacs unassociated with another base; also that in the ordinary conditions of analyses magnesia is powerless to entirely displace the ammonia. With certain salts, such as ammoniaco-magnesian phosphate, the displacement is extremely slight or nil. These results must henceforth be taken into account in the analysis of earths and of other products containing organic matter associated with the phosphates or with magnesia.—On a reindeer's antler embellished with carvings found by M. Eugène Paignon at Montgaudier, by M. Albert Gaudry. This relic of the reindeer age ranks among the most interesting animal and human remains in recent years discovered by M. Paignon in the Montgaudier Caves, Tardoire Valley, Charente. It is pierced with a large hole and covered with carvings executed with such a sure hand and sentiment of form that it shows even to greater advantage under the magnifying glass than when viewed with the naked eye. One face shows two seals (*Phoca vitulina* and a larger perhaps of different species), a fish (a salmon or trout), and three twigs of plants. On the other side are two long slender animals, apparently eels, three other animal figures exactly alike but indeterminable, and an insect. This specimen of prehistoric art, of the authenticity of which there can be no doubt, has been presented by the finder to the Museum, together with several other objects from his valuable collection.—On the real position to be assigned to the fossil flora of Aix in Provence (continued), by M. G. de Saporta. The conclusion already arrived at on stratigraphic grounds, that this flora belongs to the triple series of the Upper Eocene, Tongrian, and Aquitanian, is here confirmed by the Palæontological indications themselves.—On the development in series of the potential of a homogeneous revolving body, by M. O. Callandreau.—On the variations of the absorption-spectra in non-isotropic mediums, by M. Henry Becquerel. Apart from certain anomalies here described, it may be generally assumed that for each absorption-band there is a single system of three principal rectangular directions, of such a nature that the intensity of a luminous vibration proceeding from a crystal parallel to the direction of the incidental vibration may be represented by the form $I = (a \cos^2 \alpha + b \cos^2 \beta + c \cos^2 \gamma)^2$, where α, β, γ indicate the angles of direction of the vibration with the principal directions, and a^2, b^2, c^2 the principal intensity of the radiation in question. This hypothesis seems to be confirmed by photometric measurements executed with plates of epidote.—On the decomposition of hydrofluoric acid by an electric current, by M. H. Moissan.—Note on urethane regarded from the standpoint of chemical analysis by M. Georges Jacquemin.—Action of some organic chlorides on diphenyl in the presence of the chloride of aluminium, by M. P. Adam.—On the normal propylamines, by M.

C. Vincent. The results of the author's researches are: (1) The separation of the three normal propylamines; (2) the discovery of nitrosodipropylamine; (3) the determination of the physical constants of di- and tripropylamine and of nitrosodipropylamine. —On a new creatinine (ethylamido-acetocyamidine), and on the formation of the creatinines and creatines, by M. E. Duvillier. From the author's experiments it follows, so far, that the action of cyanimide on the starch acids consists essentially in the formation of creatinines, that of creatines taking place only in a very few cases.—On a combination of stannic chloride with hydrochloric acid (chlorostannic acid), by M. R. Engel.—On the alcoholate of potassa, by M. E. J. Maumené. Referring to M. Engel's note in the last issue of the *Comptes Rendus*, the author points out that he had already determined and announced an alcoholate of potassa so far back as the year 1872 (*Les Mondes*, December 19, 1872).—Note on the antennæ of the Eunicians, by M. Et. Jourdan.—On the effects of pollinisation in the orchid family, by M. Léon Guignard. A series of experiments is described which the author has carried out for the purpose of determining the varying interval which intervenes between pollinisation and fertilisation in this group of plants.—On the amphibolic schists and gneiss, and on the limestones of Southern Andalusia, by MM. Ch. Barrois and Alb. Offret.—Fresh experiments with balloon photography: ascent of MM. A. and G. Tissandier and P. Nadar, by M. G. Tissandier. During this ascent, which took place on July 2, and lasted nearly six hours, the altitude never exceeding 1700 metres, M. Nadar took no less than thirty instantaneous photographs; of these about a dozen constitute undoubtedly the finest series of negatives yet obtained from a balloon. Amongst them were two views of Versailles at 800 metres; one of Sèvres at 600 metres; one of Ballème (Orme) at 900 metres; several perspectives of Saint-Remy (Sarthe), some at 1200 metres. During a second ascent the following week, M. Nadar secured three good views of Champigny and the banks of the Marne. These experiments place beyond all doubt the success of aërial photographic operations.

BERLIN

Physical Society, June 4.—Dr. Pringsheim spoke on a new application of the telephone for the measurement of electrical resistances, a purpose for which it had already been brought into use by Prof. Kohlrausch in cases in which the resistances were measured by means of alternating currents—in cases, that is, of fluid conductors and also in the case of wires. Dr. Pringsheim had, however, observed that in the measurement of wire-resistances by means of alternating currents the determinations by the telephone did not always concur with those of the galvanometer, and varied very much with repeated measurements. He therefore applied the telephone for measurement by means of a constant current, and that in the following manner. In the Wheatstone bridge the circuit usually occupied by the galvanometer was of constant resistance. The four sides of the wire arrangement contained the wire the resistance of which required to be measured, and the rheostat. The two free angles of the square were connected by a wire circuit in which was placed a telephone. So long as the resistances of the two sides of the bridge were not perfectly equal, a part of the current flowed through the telephone circuit, and each time this was opened a snapping was heard in the telephone. The rheostat resistance was then changed till nothing was heard on opening the telephone circuit. The sensitiveness of this method was equal to 0·04 per cent. of the total resistance.—Prof. von Helmholtz reported on his most recent investigations, which respected the "doctrine of the maximum economy of action," and communicated the interesting history of the understanding of this principle. The doctrine was first propounded by Maupertuis in 1744 in a treatise laid before the Paris Academy. This treatise contained, however, no general statement of the proposition, nor did it define the limits of its applicability, but only adduced an example. This example was, in accordance with the present state of our knowledge, not pertinent, and had no relation to the principle of the *actio minima*. Two years later Maupertuis propounded his principle before the Berlin Academy, proclaimed it to be a universal law of nature and the first scientific proof of the existence of God. On this occasion, too, he did not prove the proposition nor determine the limits of its applicability, but only supported it by two examples, one of which alone was correct. This principle, propounded with such grand solemnity, but so weakly supported, was violently attacked by König of Leipzig, and just as keenly defended by Euler. This mathematician likewise failed to furnish the proof, which was not possible till after the investigations of Lagrange. The form in which the principle of the *actio minima* now existed was given to it by Hamilton, and the Hamiltonian principle for ponderable bodies was in complete harmony with the Lagrange propositions. The elder Neumann, Clausius, Maxwell, and the speaker had already extended the Hamiltonian principle to electro-dynamics. For this purpose, and in order to be able to subordinate to it all reversible processes, the speaker had undertaken some transformations of it, and had introduced into it the conception of the "kinetic potential." In the form it had thus attained the Hamiltonian law—the old principle of the *actio minima*—had in point of fact universal validity. It had just as wide an application as had the law of the conservation of energy, and revealed a whole series of mutual relations between the different physical processes. In his communication Prof. von Helmholtz gave only a quite general view of his investigations.

BOOKS AND PAMPHLETS RECEIVED

"Studies from the Biological Laboratories of the Owens College," vol. i. (J. E. Cornish, Manchester).—"Exterior Ballistics," by J. M. Ingolls (Van Nostrand).—"Essays relating to Indo-China," 2 vols. (Trübner).—"Fifth Annual Report of the United States Geological Survey," by J. W. Powell (Washington).—"The Chemistry of Wheat Flour and Bread," by W. Jago (Brighton).—"Annual Report of the University College and Free Library Committee of the Borough of Nottingham," 1885-86.—"Report on the Progress and Condition of the Botanic Garden and Government Plantations of South Australia, 1885," by R Schomburgk (E. Spiller, Adelaide)—"Longman's School Geography," by G. G. Chisholm (Longmans).—"Annuaire Geologique Universel et Guide du Geologique, 1886," vol. ii., by Dr. Dagincourt.—"Proceedings of the American Association held at Philadelphia," 2 parts (Salem).—"The Law of Storms," second edition, by W. H. Rosser (Norie and Wilson).—"Fourth Report of the U.S. Entomological Commission" (Cotton Worm and Boll Worm), by H. Riley (Washington).—"Progress of Astronomy, 1885," by W. C. Winlock (Washington).—"Bulletin de la Société Impériale des Naturalistes de Moscou," Nos. 3 and 4 (Moscou).—"Original Mittheilungen aus der Ethnologischen Abtheilung der Königlichen Mus. zu Berlin," Erster Jahrgang, Heft 1, 2, 3 (Spermann, Berlin).

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