THURSDAY, OCTOBER 3, 1878

DOBSON'S CATALOGUE OF BATS

Catalogue of the Chiroptera in the Collection of the British Museum. By George Edward Dobson, M.A., M.B. London. (Printed by Order of the Trustees. 1 vol., 8vo. 1878.)

THOUGH Mr. Dobson's work is modestly termed a "Catalogue," it amounts, in fact, to a complete monographic essay on what has hitherto been justly regarded as the most difficult and the least understood, as it is the most numerous, of all the orders of mammals. Not only are the families and genera of the Chiroptera well characterised in this volume, and all the known species described in concise though sufficiently explicit terms, but synopses of the members of each genus are added in order to facilitate their determination, and excellent notes on the comparative anatomy, habits, distribution, and position of these animals are given, whenever such information is available. Mr. Dobson, it is true, has had unusual opportunities in dealing with this subject, but it is not the less to his credit that he has taken such good advantage of them. Having commenced his studies upon the bats during his official residence in India, he has been able to make himself personally acquainted with the forms inhabiting that country, and likewise to examine the types of Blyth's descriptions in the Indian Museum at Calcutta, without sight of which it would have been impossible to recognise what was intended by them. In this country the late Dr. Gray turned his attention at various times to the Chiroptera, and besides describing numerous species even more hastily and imperfectly than Mr. Blyth, indulged himself in the evil practice of altering some of the types upon which he had found his genera and species. Having the national collection at his command, Mr. Dobson has been able to reduce all these eccentricities into order. On the continent the accomplished zoologist of Berlin, Dr. W. Peters, is almost the only naturalist who has of late years worked at this perplexing group of mammals. Dr. Peters has published many excellent memoirs on various genera of bats in the *Monatsberichte* and *Denkschriften* of the Berlin Academy, in the course of which he has given us an account of his examination of numerous obscure types of the older author. Mr. Dobson has worked up the results of these memoirs into his monograph, and has at the same time had the advantage of examining in the Museum of Berlin the materials upon which Dr. Peters has based many of his conclusions. Mr. Dobson has also visited the great museums of Leyden and Paris, and has studied the specimens described by Temminck, Geoffroy St. Hilaire, and A. Milne-Edwards, belonging to these collections. In fact he has had under his eyes nearly all the available materials for a study of the group, unless it be the specimens collected by Natterer in the Imperial Zoological Cabinet at Vienna, and a few types lately described by Mr. Allen in America. Under these circumstances Mr. Dobson's so-called "Catalogue" has, as we have already remarked, become a monograph of a very high order of merit, and one which reflects the greatest credit upon the talents and the industry of the author.

Mr. Dobson recognises 400 species of the order Chiroptera, which he divides primarily into "Megachiroptera" and "Micro-chiroptera." We do not quite see the advantage of these newly-coined names over the more usually employed terms of "Frugivora" and "Insectivora," even if they had been classically compounded, which, unfortunately, is not quite the case. Certain it is that the new terms are not more absolutely true than the older ones, as some of the smaller "Megachiroptera" are inferior in size to the larger "Microchiroptera." About seventy species of the Frugivorous bats are allowed full rank in the present work, the author, who holds very sound views on the true limits of species, having reduced to the grade of sub-species some of the forms recognised by previous writers. The more numerous "Micro-chiroptera" constitute five families, namely the Rhinolophidæ, Nycteridæ, Vespertilionidæ, Emballonuridæ, and Phyllostomidæ, according to Mr. Dobson. This arrangement is not very different from that of Dr. Peters in 1865. Dr. Peters' "Megadermata" do not quite correspond to Mr. Dobson's "Nycteridæ," and Mr. Dobson puts the "Brachyura" and "Molossi" of Dr. Peters together in his family "Emballonuridæ." There are other minor differences, but it is satisfactory to see that these two great authorities on an obscure group of mammals are so nearly agreed as to their general arrangement.

Mr. Dobson has not made any suggestion as to the special use of the extraordinary adhesive discs which are attached to the inferior surface of the thumbs of *Thyroptera tricolor*, except by designating them as "highly specialised climbing organs." This they certainly are, but to climb what are they highly specialised? We have been told by one who has observed them in their native haunts that these abnormal bats are always found adhering to the smooth stems of certain palm-trees on the upper Amazons, and it is for this purpose, no doubt, that these peculiar suckers are provided. As regards the vexed question of the true blood-sucking bats, Mr. Dobson seems to adhere to the now generally-received opinion that the only certainly-known sanguivorous species are the two Desmodontes (*Desmodus rufus* and *Diphylla ecaudata*), in which the alimentary canal is specially modified in relation to their peculiar diet. *Vampyrus spectrum*, formerly considered so formidable a blood-sucker, is probably purely frugivorous, and older writers have made similar accusations against certain species of *Glossophaga* and *Artibeus*. But *Desmodus* is the only culprit that has been actually "caught in the act," and naturalists are always somewhat incredulous in cases of merely circumstantial evidence. As regards the peculiar structure of the stomach of the Desmodontes it is not quite true, as stated by Mr. Dobson, that no other zoologists but Prof. Huxley and Dr. Peters "seem to have been aware of this remarkable departure from the simple type of that organ found in all other Micro-chiroptera." As Herr v. Pelzeln has lately told us,[1] this peculiarity did not escape the vigilant eyes of the late Johann Natterer, who recorded it in his notebook in 1824, although his remarks were never published, and, if we are not mistaken, Prof. Reinhardt has also noticed it.

Mr. Dobson's letter-press is illustrated by thirty litho-

[1] Sitz. k.k. zoolog.-botan. Ges. in Wien, vol. xxviii.

graphic plates drawn under his superintendence by R. Mintern. Although not so finished in execution as those of the late Mr. Ford, or quite so clear in detail as what Franz Wagner has done for Dr. Peters in the same style, these plates form a great addition to the volume, and exhibit some of the special structures of the group in a very efficient way.

Of the general merits of the Zoological Catalogues of the British Museum, and of the credit due to the staff of the Zoological Department for their preparation in the face of many difficulties, we have spoken in a previous notice of one of this same series.[1] It is much to be regretted, however, that more pains are not taken to make the existence of these most valuable publications known to the world. No publisher's name being on the title-page, it is difficult for the general public to know how to procure them, and no information on the subject is given in the volumes themselves. So far as we know, they are not advertised in any way, and no copies are sent out for review—certainly not to the office of NATURE;[2] so that it is only by chance that one becomes aware of their issue. On the Continent there are many complaints about the difficulty of procuring copies, and naturalists in London receive frequent applications from their brethren abroad on this subject. This might be all remedied by putting a publisher's name on the title-page—a course adopted by all our principal scientific societies for their publications—or even by adding to each volume a list of the series, with some directions as to how and where they are to be obtained. Another mystery connected with these catalogues which we have never been able to understand is why the authors of them should not be allowed to write their own prefaces. In some of the older volumes even the author's name is not given on the title-page. This privilege has been conceded of late years, but the prefaces continue to be written by the "keeper of the department." We are told this is a "regulation of the trustees"—an answer given, we may observe, about many other rules and regulations at the British Museum, of which no one can understand the utility.

TIDY'S "HANDBOOK OF CHEMISTRY"

Handbook of Modern Chemistry, Inorganic and Organic, for the Use of Students. By Charles Meymott Tidy, M.B., F.C.S. (London: J. and A. Churchill.)

THIS work is divided, as is usually the case with chemical text-books, into three large divisions; the first containing the chemistry of non-metallic bodies, the second the chemistry of the metals, and the third the chemistry of organic substances.

In the first two chapters, preliminary to those discussing systematically the natural occurrence, preparation, and properties of the non-metals, the author describes the more general principles involved in the science, embracing such topics as nomenclature, atomic and molecular combination, combination by volume, atomicity and quantivalence, &c. The subjects here touched upon are clearly dealt with, and Mr. Tidy's style of writing cannot fail to attract the attention of the reader.

The subsequent portion of the book, consisting of Chapters III. to IX., embraces the consideration of the individual properties of the different non-metallic elements; and although this part of the work abounds in valuable and, as far as we can see, accurate information, there is an important point with regard to it upon which we cannot thoroughly congratulate the author; namely, the order in which he has arranged the non-metallic elements. He commences with oxygen and finishes with hydrogen. We cannot at this moment see, nor can we find any explanation in the preface or otherwise, stating why this particular order should be adopted; and we are inclined to think that, for the sake of instruction in chemical order and classification, it indicates a defective appreciation of the wants of the student. It appears to us that, keeping this point in view, the order of such a text-book as Mr. Tidy's should be that in which the elements forming the least complex compounds are first taken, then those which possess a larger number of compounds and of a more complicated nature.

This becomes evident if it be considered what the student is met by in reading this portion of the book, where, instead of first being made acquainted with the properties of hydrogen, the body now almost universally adopted as our standard of reference for the atomic weights of the elements, for the densities of gases, &c., he has to consider oxygen "a common and important substance, certainly," but not one which is now taken as our standard, or which forms the simplest combinations, so far as its own relations are concerned, with other bodies. The reader then passes, in the next chapter, to the consideration of the group of elements, consisting of fluorine, chlorine, bromine, and iodine; bodies having a simpler volume relation to hydrogen than oxygen has: and he is then introduced to a long series of compounds, the oxyacids of the halogen series, where three elements take part in the combination before he has become acquainted with compounds containing only two, such as hydrochloric acid or water. Nay, more, he has to consider acid bodies containing hydrogen—reads equation after equation in which the body water occurs as a product of decompositions, without his previously having learned anything either about the preparation and properties of hydrogen, or the composition of water.

Again, in the arrangement of the subjects treated of in the chapter dealing with the special consideration of hydrogen (Chap. IX.) we think there is room for improvement; and that it would be better to adopt an arrangement depending on the simplest volume relations of the substances, placing them in the series monatomic, diatomic, triatomic, and so on, instead of first taking water where the ratio of hydrogen to the other substance is 2 : 1, then the halogen compounds of hydrogen where the ratio is more simple, viz., 1 : 1, then its compounds with nitrogen, phosphorus, and arsenic, where the ratio is 3 : 1, then back again to sulphuretted hydrogen, where the ratio is 2 : 1, and finally, to the simple compound of carbon and hydrogen with the ratio 4 to 1. If the student is at all thoughtful, and has paid any attention to the sections on "combination by volume," &c., which we have already stated to be clearly written, he will find himself at the end of the consideration of the non-metals rather at a loss to form any idea of order or classification as regards chemical bodies.

[1] See our review of Sharpe's "Catalogue of Birds," NATURE, vol. xvi. p. 541.

[2] Since the above was in type a copy of Dobson's "Catalogue" has been sent us by the author.—ED.

In the next portion of the work, comprehending Chapters X. to XVIII., devoted to the description of the metals, Mr. Tidy has introduced some very useful tables, in which he gives, under the more important metals, lists of their salts, with the different acids, as well as the common and constitutional formulæ of the compound, and in many cases the molecular weight, specific gravity, and percentage of metal in the salt. This tabular form has not usually been systematically adopted in text-books, and has many advantages, more especially when the work is used for consultation.

In connection with this part, however, which embraces also the general consideration of acids, bases, and salts, it is to be regretted that the definition of an acid comes so late in the volume as p. 252; we should have expected to have found some description at least of an acid a little earlier. With respect also as to what "an acid is," the index of the work is misleading; thus, for instance, on consulting it with regard to the above point we are referred to p. 527, where we find the definition of an organic acid; the term acid in its ordinary sense being only found under the term salt. It may be urged that an acid is a salt of hydrogen, but it is rather too much to expect one who may be reading a chemical text-book for the first time to know all this, more especially as he meets with no explanation of the matter as far as we have found till p. 252.

The last part of the work, comprising Chapters XIX. to XXXI., is occupied with the consideration of the organic division of the science. We regret that space does not permit us to enter very fully into a review of this portion of the book, but as far as we can judge the information contained in it is accurate and well arranged. Here we are glad to see, as in the chapters describing the metals, tables giving the names, formulæ, specific gravities, boiling points, &c., of the different substances arranged in their respective groups or series. These tables we have no doubt will prove of very great use to the student. An appendix contains an account of the recent experiments of Pictet on the liquefaction of oxygen, &c., and a description of Mendeleeff's "Law of periodicity of the chemical elements." Great clearness in style is given to the book by the tables just referred to, and to the methodical manner in which Mr. Tidy has arranged the individual consideration of each element under several heads, as "(1) History, (2) Natural History, (3) Preparation, (4) Properties—(α) sensible, (β) physical, and (γ) chemical," and so on; but notwithstanding this arrangement, which adds to the value of the book, we regret the order in which the author has placed the non-metallic elements, which we cannot help regarding as defective in the case of a text-book designed for the use of students.

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 ensure the appearance even of communications containing interesting and novel facts.*]

On the Proposed Observatory on the Summit of Mount Etna

Two years ago (September 22, 1876) Prof. Tacchini, of Palermo, read a paper before the Accademia Gioenia of Catania "Sulla Convenienza ed utilità di erigere sull' Etna una Stazione Astronomico-Meteorologica" (NATURE, vol. xv. p. 262). He proposed herein that an observatory should be erected at the Casa Inglesi, which is situated at the foot of the cone of the great crater 9,652 feet above the sea. In it daily observations, both astronomical and meteorological, should be taken during six months of the year, and the telescope should then be removed to Catania and the observations continued.

No more has been heard of this scheme but we sincerely trust that it will not fall to the ground, and that, if need be, our own astronomers will come forward to promote so good a work. No one who has not witnessed a cloudless starlit sky on a perfectly calm night from an elevation of two miles, can realise the difference between it and the same sky seen from the surface of the earth. When I ascended Etna in August, 1877, I was particularly struck by the extraordinary brilliancy of the midnight sky. It was one blaze of brilliant light. Myriads of stars which I had never seen before were visible, and the whole sky was studded with stars of every magnitude, colour, and brightness. The meteors which flashed across the sky were too numerous to count, and the stars themselves shone with extraordinary scintillations. I specially noticed a curious effect for which it is not easy to account, viz., the apparent lowness of the sky. It appeared to be almost pressing down upon one's head, and the larger stars seemed to be suspended below the sky. A good telescope brought to bear upon such a sky would reap a harvest of results. Tacchini noticed that Venus cast shadows, and Sirius appeared to rival Venus.

The observatory on Etna should be constructed on the most sheltered side of the mountain. It might be placed a little to the west of the Torre del Filosofo, the traditional observatory of Empedokles. It could be built of lava collected on the spot, and it would not be difficult to sink the foundations to a depth sufficient to ensure steadiness. It should be telegraphically connected with the observatory at Catania, and barometric and thermometric readings should be taken at the same instant of time at the two stations. It should be provided with a good 8 or 10-inch refractor, the lenses of which could be transported to a duplicate mounting in the observatory of Catania during the winter months. Moreover, it should possess a complete set of self-registering seismological instruments similar to those employed by Palmieri, and now exhibited in the Paris exhibition. Good spectroscopes should be provided, and a set of instruments for magnetic observations.

We are quite confident that considerable results would accrue to many of the sciences if systematic observations were carried out under the proposed conditions which have never yet been attempted, and we trust that astronomers both at home and abroad will not allow the subject to fall to the ground.

G. F. RODWELL

Compound Lightning Flashes

IN NATURE, vol. xviii. p. 67, an instance is given of several flashes of lightning following in the same path, and information concerning similar observations is asked for.

In almost every tropical thunderstorm the phenomena may be seen; to best advantage when the storm is distant. Three, four, and even more discharges may take place, the second and remaining flashes following in rapid succession through the identical path taken by the first. The intervals between the flashes vary; one may follow another so rapidly as to seem merely like a bright pulsation in the first, or there may be an appreciable interval of darkness; but it is certain that, if the eye can be trusted, these secondary flashes follow the exact course of their primary. The reason of this may be looked for in the heating effect of the lightning. The partial vacuum caused by the first discharge offers a line of comparatively small resistance to succeeding currents.

The singular part of the phenomenon is the rapidity with which the electricity must form or collect to admit of several discharges taking place at the same spot, for I do not think the secondary flashes can be regarded as merely residual.

During a severe storm at Mangalore on the 28th of last April two military buildings were struck by lightning, and, from the numerous paths taken by the electricity through the buildings, in its passage to the earth from the points struck, I was led to think the damage might be the result of these *compound* flashes; for it was conceivable that the destruction caused by each discharge might increase the resistance of the path taken, leaving succeeding flashes to follow in fresh directions of less resistance. New lines might indeed be opened out by fragments of metal, such as nails, &c., scattered by the explosions.

In the case mentioned above, it was difficult, without some such theory, to account for the breaks in the courses followed by the electricity. E. H. PRINGLE

Bath, October 1

Gyno-Diœcious Plants

DURING the past summer I have found the following species in a gyno-diœcious condition, namely, *Ranunculus acris*, *R. repens*, *R. bulbosus*, and *Stachys germanica*, all of which have the corolla considerably reduced in size, and the stamens in *R. acris* and *S. germanica* either absent or reduced to scale-like bodies devoid of pollen. In *R. repens* and *R. bulbosus* the stamens are not so much reduced, but so far as I can judge they produced little or no pollen. The female form in *R. acris* is very common in Lancashire, but I failed to find any on the Lincolnshire coast although I searched carefully for it. In *R. repens* the female form is very rare, having seen only about thirty plants in all. I have also found the *Geum rivale* to be andro-monœcious. So far as I can ascertain these plants have not been noticed in the state described above.

Ashton-under-Lyne THOMAS WHITELEGGE

Wasps Under Chloroform

A FEW days ago a friend told me that she had often placed a bee under chloroform, and that the victims when they found they must die invariably brought their stings to their mouths and sucked the little drop of poison into their mouths. She offered to show me the experiment and endeavoured to catch a bee, but failing to do so she caught a wasp, an insect upon which she had not previously experimented in this way, and we both eagerly watched to see if the wasp would behave as the bees had done under the influence of the narcotic.

The wasp being put under an inverted tumbler in company with a piece of paper saturated with chloroform, in a very few seconds the insect fell on its back and almost immediately afterwards curled up the tail with the sting protruded and a drop of clear fluid on the end of the sting. The sting was brought to the mouth and the drop of fluid disappeared. The wasp then became motionless. After a few seconds the tumbler was removed and the air allowed to play freely on the insect, but no sign of life appeared, except once a slight twitch of the wing. To test whether the insect was really dead my friend placed it in a butterfly cage and left it out of doors all night. Next morning the wasp had disappeared; having perhaps crawled out by a little chink in the cage door.

Can you tell me whether so curious an action of these insects when subjected to chloroform is well known? Does it fulfil any good purpose? Is the poison a narcotic itself and taken by the insect to dull its pains when death seems inevitable? The revival of the wasp appears to show that neither the chloroform nor the poison of its own sting is deadly to the insect. W. M.

Clevedon, September 21

"Mercator" the Geographer

IN Prof. Huxley's "Physiography" it is stated that the real name of "Mercator," of "projection" fame, was Gerard Kauffmann. In a recent number, however, of the popular German journal, the *Gartenlaube*, there is a woodcut of Mercator, taken from an old sketch, under which is the legend—*Gerard Kremer genannt Mercator*. Now, as the word Kremer, or Krämer, means a small retail shopkeeper, the Latin pseudonym is equally applicable, although there is an appreciable difference, meaning excluded, between the two German surnames.

J. C. G.

Our Natural History Collections

IN your recent articles on "Our Natural History Collections," in which you criticised the Act of Parliament just passed authorising the removal of the natural history collections in the British Museum, I was surprised not to find any mention of the third clause, which inaugurates a new and enlightened policy in the disposal of duplicates. The clause was inserted at the instigation of Mr. A. J. Mundella, M.P., and Mr. J. Chamberlain, M.P., and is as follows:—"The trustees of the British Museum may also give away any duplicate works, objects, or specimens not required for the purposes of the museum, provided always that the powers hereby conferred shall not extend to any duplicate works in the royal library of King George IV., or in the Crackerode, Grenville, or Banksean libraries, or to any objects presented to the museum for use or preservation therein."

This important departure from the previous holdfast policy of the British Museum will be hailed with delight by all provincial students of natural history, as will also the paragraph in Prof. Sir C. Wyville Thomson's report to the British Association, referring to the disposal of the *Challenger* collections (*vide* NATURE, vol. xviii. p. 534).

Public museums are springing up all over the country, and any one acquainted with them knows well the difficulty of forming a natural history collection properly suited to educational requirements. If the power now conferred on the trustees of the British Museum is wisely and liberally used, I think as much material will be found stored away as will furnish provincial museums with the specimens required to make them educationally valuable. E. H.

Sheffield, September 26

OUR ASTRONOMICAL COLUMN

BIELA'S COMET.—The great swarm of meteors through which the earth passed on the evening of November 27, 1872, and which were found to be moving in the orbit of Biela's comet, must have been descending to a perihelion passage one month later, or about December 27·6 G.M.T. The comet not having been observed as such since the autumn of 1852, when both parts into which it was separated in 1846 were recovered, we may take this date as a new point of departure, assuming for the present that in following the great assemblage of meteoric bodies seen in November, 1872, we are following what now remains of the comet.

Hubbard's elements of the S. F. nucleus of 1852, with Michez's perturbations by Jupiter and Saturn, give the following elements for 1866, the latest year to which perturbations have been calculated:—

Perihelion Passage, 1866, January 27·6968 G.M.T.

	°	′	″
Longitude of perihelion	109	39	48
,, ascending node	245	43	42
Inclination	12	22	3
Angle of eccentricity	48	46	19·4
Log. semi-axis major	0·5505333		

We know that the comet did not arrive at perihelion at or near the above date in 1866, and hence that disturbance of its motion from an undiscovered cause must have taken place some time in the interval 1852–66. The period of revolution belonging to this orbit is 2445·67 days. There is no reason to suppose that the swarm of meteors is revolving in a shorter period, and we may consequently assume that it will not be again in perihelion before the date, which this period will give, if reckoned from December 27·6, 1872, or September 8, 1879; how much later the perihelion passage may fall it is impossible to foresee. We refer to this point on the present occasion with the view to suggest that a close watch for meteors of the Biela-comet stream should be instituted when the earth again passes the descending node of the comet's, orbit on November 27 next. With perihelion passage on September 8, 1879, the main cometary body would be in a true anomaly of −135° 15′. On December 6, 1798, when Brandes witnessed a great meteoric display, as the earth traversed the comet's orbit, it was in a true anomaly of about −103°, but in 1838, when under similar conditions meteors were observed in large numbers in Europe, Asia, and America, December 5–8, the comet's true anomaly was about −128°.

As regards the recovery of the comet in 1879, though perhaps not hopeless, a very strict examination of the heavens in the neighbourhood of its projected track with considerable optical power may be necessary, and it will be particularly a case where the Astronomer-Royal's principle of mounting involved in his "orbit-sweeper" might be brought into useful requisition.

ENCKE'S COMET.—Mr. John Tebbutt, of Windsor, New South Wales, announces his re-observation of the comet of Encke, in the evening twilight on August 3, with the aid of the late Dr. von Asten's ephemeris, which had reached him on July 22. On August 5 it was pretty bright in a 4½-inch refractor, notwithstanding the moonlight, and Mr. Tebbutt hoped to secure a good series of positions. This comet has not passed unobserved at any appearance since its periodicity was discovered by Encke nearly sixty years ago.

BRORSEN'S COMET.—Prof. Schulze, of Döbeln, has published an ephemeris of Brorsen's comet of short period for the reappearance in 1879, founded upon a new discussion of the observations at the last two returns, and the application of the perturbations of Venus, the Earth, Mars, Jupiter, and Saturn. The comet will arrive at perihelion on March 30, and at its least distance from the earth on May 9, about which time its north declination will exceed 65°, so that it will be very favourably situated for observation in these latitudes. Prof. Schulze thinks the comet may be detected at the southern observations before the end of February.

NEW MINOR PLANETS.—Two new minor planets have been added to the list: the first detected by Prof. Peters, at Clinton, U.S., on September 18, the second by Prof. Watson, at Ann Arbor, on September 22—thus raising the number of known members of the group to 190.

AUGUSTUS HEINRICH PETERMANN

WE regret to record the sudden death, at Gotha, on September 26, of Dr. Augustus H. Petermann, one of the first cartographers of the present day. He was born at Bleicherode, in the neighbourhood of Nordhausen, Prussia, April 18, 1822. Although destined by his parents for the church, a pronounced taste for geographical study led to his entrance, at the age of seventeen, into the Geographische Kunstschule, founded shortly before at Potsdam, by Berghaus. Here, under the guidance of this famous geographer, he made rapid progress, and soon attracted the attention of leading *savants*. Among others Humboldt became interested in him, and entrusted him, when but nineteen years of age, with the preparation of the map accompanying his well-known work on Central Asia. Four years later, in 1845, he went to Edinburgh, in order to assist in the preparation of the English edition of the great Physical Atlas of Berghaus, issued by Johnston. Accompanying Petermann to Edinburgh was Henry Lange (now Dr. Lange, of the Berlin Statistical Bureau). These two, along with the late Keith Johnston, made an interesting tour through the Scottish Highlands, one result of which was a sketch or diagram of the Grampian range by Petermann, which he afterwards, we believe, published in London. In 1847 he settled in London, and was promptly elected into the Royal Geographical Society. His seven years' residence in London (1847-54) was one of continuous activity. Aside from the numerous maps which he executed, he contributed regularly to the *Athenæum* a *résumé* of the progress of geographical discovery, and issued, in union with Thomas Milner, an "Atlas of Physical Geography," and a fine folio atlas to illustrate Barth and Oberweg's travels in Africa. Two other maps which Petermann brought out during his stay in London still maintain their place on Stanford's list—a hydrographical and a population map of the British Islands. It was the publication of these maps, we believe, which enabled him to obtain the favourable notice of Baron Bunsen, who materially assisted Petermann in his progress. His connection with English publishers has always been close, and the last edition of the "Encyclopædia Britannica" contains a number of admirable geographical articles from his pen. In 1855 he returned to his native land to take the management of Justus Perthes' Geographical Institute in Gotha, where an unlimited field was offered to his restless activity. In the same year he commenced the publication of the *Mittheilungen*, the successor of the *Geographisches Jahrbuch*, started by Berghaus. Under his careful editorship this periodical has become almost indispensable to those desiring to keep *au courant* with the progress of geographical discovery. No small portion of its rich and varied contents, as well as of its finely-executed maps, were due directly to Petermann. As cartographer Petermann was unwearied, and a constant succession of admirable maps have been executed by him during the past twenty-five years. Among these we might mention especially a great part of the magnificent collection forming Stieler's "Grosser Atlas," completed two years since; the map of the United States (1875), regarded by the government officials of that country as the most perfect extant; the maps accompanying the African travels of Barth and Rohlfs; and the lately-issued charts of the Arctic regions and the Turkish empire.

It is, however, chiefly by his criticism, his advice, and his enthusiastic, unwearied support of all attempts at geographical discovery, that Dr. Petermann has rendered his greatest services. Standing practically at the head of European geographers, the depositary of all that was being attempted or had been executed, esteemed and regarded by the authorities of the leading nations, he has enabled, by his personal efforts and wide-spread influence, many of our prominent explorers to find the necessary sinews of war, and successfully realise their plans of travel. Two great departments of geographical exploration have specially possessed his sympathies. The first was that of Arctic exploration, and dates from the interest excited during his residence in England, by the expeditions sent forth in search of Franklin. It was almost entirely due to his exertions that the German government equipped the successive expeditions of Werner (1865), Koldewey (1868), and Koldewey and Hegemann (1869), all of which aimed at the exploration of the east coast of Greenland—Petermann's favourite route for approaching the Pole. His advice was likewise of material assistance in the preparations for the late Austrian, English, Dutch, and Swedish expeditions, and few voyages to the icy regions have been undertaken of late years without consultation with Petermann on the general plan.

A still deeper interest was shown by him in the matter of African travel. The important expedition of Barth, Overweg, and Vogel, in 1849, was instituted by the Prussian Government, chiefly on the recommendations of Bunsen and Petermann. Heuglin's and Munzinger's expedition in 1861 was also due entirely to his instigation. Rohlfs' journey in Morocco, as well as Mauch's expedition in South Africa, would have been impossible without his assistance, and his name is closely associated with the important expeditions of Schweinfurth and Nachtigal.

The numerous contributions of Petermann to geographical literature are contained in the *Mittheilungen*, with the exception of those published in English. Of late years he has occupied the chair of geography at the Gotha Polytechnic.

As we have said, the *Geographische Mittheilungen* has become indispensable to all who wish to keep pace with the progress of geography; and from its pages a fair idea may be obtained of the all-comprehensiveness of that department of knowledge. We are glad to learn, from a circular signed by Dr. Behm, the efficient colleague of Petermann, that this *facile princeps* of geographical journals is to be continued. We trust its comprehensiveness, thoroughly scientific character, and general high standing will be maintained, and that it will continue a permanent monument to the genius, knowledge, and zeal of its founder.

THE NORWEGIAN NORTH ATLANTIC EXPEDITION

THE *Vöringen* left Hammerfest on July 29 on its last cruise. On the 31st, at noon, Bear Island was reached. Here the expedition was kept till August 3, the weather being too stormy to allow sea work to be done. In the night of August 1-2 a party landed on the east side of the island, where the sea was sufficiently smooth to allow a boat to land: but foggy weather interfered with any observations of importance being made. Some birds were shot and some fossils collected. In the morning hours extensive fishing operations were carried on from the deck of the ship, now anchored in some 12 fathoms. From 4 to 7 A.M. 200 large cods were hauled. From a point about midway between Bear Island and Spitzbergen we worked first up a cross section towards west-north-west, till we found 1,149 fathoms' depth on the afternoon of the 4th. From this point the course was shaped for South Cape, Spitzbergen. At noon on the 5th we made the cape, sailed round the island lying off the cape, and entered the Stor-Fjord. Here the sun was shining and the water smooth, so Capt. Wille swung the ship for deviation. The next morning we dredged on the bank lying south-east of South Cape; here the temperature was − 1°·2 C. at the bottom, in 140 fathoms, and zero in 120 fathoms. In the upper layers the temperature was very irregularly distributed, both increasing and decreasing with depth. We went again round the islands and to the west side of South Cape, taking here a departure for a larger cross section along the parallel of the cape towards Greenland. Having crossed the Spitzbergen bank, we sounded 523, 743, 1,017, 1,429, 1,487, and 1,686 fathoms, when we at last, on August 8, were stopped by the ice in 76° 26′ N. lat. and 0° 29′ W. long. Off the Spitzbergen bank we found 0° C. in a depth of 470 fathoms. The polar current was reached in long. 5° E. Station No. 360, where we met the ice, gave the following serial temperatures characteristic of the polar current:—Surface, 3°·2 C., 40 fathoms, − 1°·3; 70 fathoms, − 0°·3; 200 fathoms, − 0°·7; 300 fathoms, − 1°·0; 1,686 fathoms at bottom, − 1°·3. On this station we lost a trawl and 2,163 fathoms of dredge rope. The sea-bottom between Spitzbergen and Greenland was very rough; the trawl or dredge seldom came up without damage or having stones inclosed, some of which were rather heavy. We sailed, on August 9, northwards along the ice, and reached our next cross section on the 10th, lat. 77° 50′, long. 0° 9′ W. The soundings were, from west to east, 1,640, 1,686, 1,333, 1,343, 948, 110 fathoms. The polar current closed in about 4° E. long. Farther east, 0° C. was found in 300 to almost 500 fathoms. On Station No. 354, lat. 78° 1′, long. 6° 54′ E., we had the great satisfaction of verifying the Swedish sounding made in 1868 at the same place by von Otter in the *Sofia*. The Swedes found 1,350 fathoms, we found 1,343. This agreement gives me great confidence in von Otter's soundings, which were made with less perfect means than ours. The Swedish deep-sea soundings in the *Sofia* extend far westwards and northwards from Spitzbergen, and are therefore of the greatest importance. From our last cross-section we took a longitudinal section parallel to the coast of Spitzbergen. The depths reached were 421 fathoms (temperature 0°·0), 905 fathoms, and 459 fathoms in lat. 79° 59′, long. 5° 40′ E. There was 0° in 390 fathoms depth. There was ice floating in the surface temperature at 5°·2. This brought our section to a close.

It appears that here on the 80th parallel, the warm Atlantic current is still running northwards, backed up on the west coast of Spitzbergen. The polar ice, driven by northerly winds, is swimming on its back, and melted gradually off just like the end of the glaciers in the summer heat of the valleys. It was apparent that the current was rather strong towards the north, the ship's place being always, by observations and bearings, found more northerly than by dead reckoning. On the open sea it was found very difficult, not to say impossible, to determine the ship's place with the ordinary accuracy. The horizon was generally—as we observed when off the shore—lifted by a sort of mirage.

On August 15 we dropped our anchor at the Norway Islands, North Spitzbergen, where we took in some ballast. In the sound, where we were lying, the beach was formed of mere loose stones, granite, apparently burst asunder by frost. Flakes and small bergs of ice sailed through the sound with the tide and were often touching the shore, but I could not observe there any sign of the ice cutting any line or mark along the beach. From the Norway Islands we went out off Hackluyt Head, where we took a sounding, passed the Smeerenberg and the South Gat, and anchored in Magdalena Bay. The Admiralty chart of the last-named places, surveyed in 1818 by Franklin and Beechy, proved very accurate. In Magdalena Bay we found a bottom temperature of − 1°·7 to − 2°·0, in exact agreement with the results formed by M. Charles Martins in 1839 in the *La Recherche* expedition. Our last visit was in the Advent Bay ice-fjord, where Capt. Wille constructed a chart of the bay, assisted by Capt. Grieg and myself, who measured the base line, some trigonometrical angles, and took altitudes for latitude and longitude. Foggy weather prevented our visit to Bell Sound. On August 23 we left Spitzbergen, and on the 26th we anchored at Tromsö. On September 4 the *Vöringen* returned to Bergen and the expedition was closed. The three summers have yielded in all 375 sounding-stations, 113 temperature series, 44 dredgings, and 42 trawlings.

H. MOHN

THE ANCIENT CAPITAL OF ITHACA

IN a recent letter to the *Times* Dr. Schliemann describes his search for the ancient capital of the island of Ithaca. He began his researches in the valley called Polis, which is in the northern part of the island, and has generally been considered as the site of the Homeric capital of Ithaca—first, on account of its name, which is the Greek word for city; second, on account of its splendid harbour, at a distance of only two miles from a small island now called Mathitarió, which, being the only one in the strait between Ithaca and Cephalonia, has naturally always been identified with the Homeric island of Asteris, behind which the suitors of Penelope were in wait for Telemachus on his return from Pylos and Sparta ("Odyssey," iv., 844-847). As a fourth reason for the identity of Polis with the site of Ithaca's capital, he mentions an acropolis which one thinks to perceive on the very steep rock, at a height of about 400 feet, on the north side of the port. Dr. Schliemann found it to consist of a very irregular calcareous rock, which had evidently never been touched by the hands of man, and can most certainly never have served as a work of defence. There can be no doubt that the name of this valley is derived not, as has been hitherto thought, from a real city, but merely from an imaginary fortress.

Besides, this valley is the most fertile spot in Ithaca, and it can therefore never have been used for the site of a city; in fact, it never yet occurred in Greece that a city should have been built on fertile land, and least of all can such have been the case on the rocky island of Ithaca, where arable land is so exceedingly rare and precious.

The island Mathitarió Dr. Schliemann visited and carefully measured. Its length is 586 feet; its breadth varies between 108 feet and 176 feet. It cannot, on account of these small dimensions, possibly be identified with the Homeric Asteris, which, as the poet says, had two ports, each of them with two entrances.

Though for all these reasons Dr. Schliemann was perfectly convinced that no city can ever have occupied the fertile valley of Polis, yet he thought it in the interest of science to investigate the matter by actual excavations. He sunk there many shafts, but in nearly all of them he struck the natural rock in a depth of 10 to 13 feet, except in the middle of the valley, which seems to have been hollowed out to a great depth by a mountain torrent. Fragments of rudely-made black or white Greek pottery and pieces of tiles were all he found. There were only a few fragments of archaic pottery for which he could claim the sixth century B.C. Tombs are sometimes found on the neighbouring heights, but, as is proved by the pottery and coins contained in them, they are of the third, fourth, or fifth century B.C. Of the same period are also the antiquities found in a cavern to the right of the port of Polis; for an inscription found there Dr. Schliemann can with certainty claim the sixth or even the seventh century B.C. Therefore, the supposition that Polis is the site of the Homeric capital of Ithaca must now be definitely abandoned.

Dr. Schliemann afterwards carefully surveyed the remaining northern part of the island, but found nowhere the site of an ancient town, except in the environs of the small building of cyclopean masonry, usually called "School of Homer," which the owner of the property has lately converted into a small church. He refused Dr. Schliemann permission to excavate in the church, but allowed him to do so in the adjoining fields, where a number of rock-cut house foundations and remnants of cyclopean walls testified to the existence of an ancient settlement. He dug there a great many holes, but always struck the natural rock in less than 3 feet, and sometimes even in a depth of less than 12 inches; thus there can be no doubt that a town has existed here in classical times, and most probably it is the very town mentioned by Scylax Per. 34, and Ptolemæus III., 14, 13.

Dr. Schliemann proceeded thence to Mount Aetos, situated on the narrow isthmus, hardly one mile wide, which joins northern and southern Ithaca. He found everywhere the purest virgin soil, except on the very crest of the ridge, where, near the chapel of Hagios Georgios, he found a very small plain with an accumulation of artificial soil 10 feet deep. He dug there two long trenches, in one of which he brought to light a terrace-wall 7 feet high, consisting of huge polygonal blocks, well fitted together; to compare this wall to the modern terrace-walls which surround it is to compare a giant's work to a work of dwarfs. Of pottery he found there nothing but a few fragments of black Greek vases. Having here also failed in his researches he most carefully explored Mount Aetos, which rises to the height of 1,200 feet from the sea, and has on its artificially, but rudely, levelled summit a platform of triangular form, with two large cisterns and a small one, and remnants of six or seven small cyclopean buildings, which were either separate houses or—and more probably—chambers of the large cyclopean mansion which is said to have stood there, and is commonly called "the Castle of Ulysses." There can hardly be any doubt that the level summit of Mount Aetos was extended to the north and southwest by a huge cyclopean wall still existing, the space between the top and the wall being filled up with stones and *débris*. Thus the summit forms a quadrangular, even platform 166 feet 8 inches long by 127 feet 4 inches broad, so that there was on the summit ample room for a large mansion and a courtyard. To the north and south of the circuit-wall are towers of cyclopean masonry, from each of which a huge wall of immense boulders runs down. But at a certain distance these two walls begin to form a curve, and ultimately join together. Two more cyclopean walls run down from the top—the one in an easterly, the other in a south-easterly direction, and join the curve formed by the two first-named walls. Lastly, he mentions a huge circuit-wall about 50 feet below the upper circuit-wall. This wall has fallen on the west side, but is in a marvellous state of preservation on the other sides. To increase the strength of the place the foot of the rock has been cut away so as to form a perpendicular rock wall 20 ft. high. In the walls are recognisable three gates. Between all those cyclopean walls once stood a city, which may have contained 2,000 houses, either cut out in the rock or built of cyclopean masonry. Of 190 of these houses Dr. Schliemann has been able to find the ruins more or less well preserved. He measured twelve of them and found them between 21 feet and 63 feet long, and 15 feet to 20 feet broad. The usual size of the rudely cut stones is 5 feet in length, 4 feet 8 inches in breadth, and 2 feet in thickness. The size of these stones by far exceeds that of the stones in the cyclopean houses Dr. Schliemann discovered at Mycenæ and Tiryns. Some of the houses consisted of only one room, others had four or even six chambers. This cyclopean capital is unique in the world, and every admirer of Homer ought to see it.

For two weeks Dr. Schliemann excavated with thirty workmen in those cyclopean buildings; but fragments of pottery, which has no resemblance to any of the Mycenæan pottery, but is much like that from the two most ancient cities at Troy; fragments of most curious tiles with impressed ornaments; also two with a sort of written characters which he has not yet had time to copy; further, the fragments of a most curious handmill—wer the only result of all his labour.

Dr. Schliemann has also commenced excavating the stalactite grotto near the little port of Dexia, which is generally identified with the port of Phorkys, where Ulysses was landed by the Phæacians, the grotto being rightly considered to be identical with the Homeric grotto of the Nymphs, in which Ulysses, assisted by Minerva, hid his treasures. But having opened a trench just before the little altar, down to the rock, without even finding a potsherd, he abandoned this ungrateful excavation. The grotto is very spacious, and it exactly answers the description of Homer, who says "that it has two entrances, one on its north side for men, and one on its south side for the immortal gods, for no man can enter by the divine door." All this is true, but by the entrance for the gods he means the artificially cut hole in the vault of the grotto, which must have served as a chimney to lead off the smoke of the sacrificial fires. From this chimney to the bottom of the grotto is 56 feet, and, of course, no man can enter by this way. From the vault of the grotto hang innumerable stalactites, which have given to Homer the idea of the stone urns and amphoras, and the stone frames and looms on which the Nymphs weave purple-coloured mantles and veils. Dr. Schliemann most carefully explored the whole southern portion of Ithaca. The town of Vathy, the present capital of Ithaca, is not yet a hundred years old, and the complete absence of ancient potsherds on the flat soil seems to prove that there has been no city or village on the site in antiquity. Before Vathy was founded the city was on a rocky height about one mile further south. On the site of the old town he found but a very small accumulation of *débris*, and no trace of ancient pottery.

Near the south-east extremity of the island, about 4½ miles from Vathy, are a number of stable-like rooms, averaging 25 feet in length and 10 feet in breadth, partly rock cut, partly formed by cyclopean walls of very huge stones, in which Homer must have seen the twelve swine stables built by the divine swine-herd Eumæus. To the east of these stables and just in front of them, thousands of very common but most ancient potsherds indicate the existence of an ancient rustic habitation, which Homer appears to have described to us as the house and station of Eumæus. This is the more probable as at a very short distance to east of this site, and near the sea, is a white cliff with a perpendicular descent of 100 feet which until now is called Korax—*i.e.*, the Raven Rock, to which Homer refers when he represents Ulysses as challenging Eumæus "to precipitate him from the great rock" if he finds that he is telling lies (Od. xiv. 398). Below the Korax, in a recess, is natural and always plentiful pure water, which the tradition identifies with Homer's fountain of Arethusa, from which Eumæus's swine were watered. Dr. Schliemann excavated as well in the stables as in front of them on the site of the rustic habitation; the stable he found filled with stones, but on the site of the house he struck the rock in a depth of one foot, and found there fragments of very interesting, most ancient, unpainted pottery, also of pottery with red bands, and masses of broken tiles.

Dr. Schliemann states that Ithaca is, like Utica, a Phœnician word, and means "colony," and that the type of the Ithacans is decidedly Phœnician. According to Homer Laertes's grandfather was Poseidon, and Mr. Gladstone is therefore perfectly right that the descent from Poseidon always means "descent from the Phœnicians."

Dr. Schliemann has obtained a new firman for Troy. He left Athens on September 18 for the Troad to continue his long interrupted excavation of Troy. His first work will be to bring to light the whole of the mansion immediately to the north and north-west of the gate, which seems to belong to the ancient city's chief or king.

ARE THE "ELEMENTS" ELEMENTARY?[1]

THE problem set before us by the words which I have chosen as a heading for this article is a vast one; unfortunately the data upon which an answer must be founded are in themselves vague and meagre. It is useless attempting to draw an exact conclusion from inexact data. If the degree of probability which attaches itself to the data is small, the probability of the conclusion being true must be yet smaller.

In the times of the ancients men do not appear to have attached any very definite idea to the word "Element." An element was a something, a material or an imaginary something—it did not very much matter which—a something which one might suppose, if one were so minded, to form a sub-stratum upon which other, apparently more complex, things rested. Fire was an element; it was supposed to enter into the constitution of matter of many kinds. Some people said they believed that fire and water formed earth of different kinds; others averred that air and water were the foundations of all things. But it was perfectly legitimate for a third person to tell the two former that they were completely in error, that *really* sulphur and salt were the primary elements, and that from these all other forms of matter arose.

No exact data concerning the possibility of transforming earth into air, or water into fire, or salt into sulphur were forthcoming. Men did not generally trouble themselves with investigations into the actual properties of the so-called elements. Everything was founded on supposition; the human mind was superior to nature, and could project itself upon nature and explain nature.

Such a method could lead to no true knowledge of natural phenomena. To-day we have altered our method of investigation. Nature presents us with a mass of materials; most of these we can decompose into two or more forms of matter, but some of these resist all efforts hitherto made to effect their analysis. The latter we call elements, the former compounds. Our knowledge is imperfect; we acknowledge the imperfection, but attempt to make the knowledge *exact so far as it goes*. Whether the so-called elements are or are not capable of further subdivision is an open question. Whatever answer this question may finally receive, the superstructure of chemical science will remain unshaken. We may find it necessary to alter the form of many statements; the facts and, I am persuaded, many of the theories, will remain.

An element is then a substance which has hitherto yielded no simpler form of matter than itself. We make the hypothesis that matter is built up or compounded of those substances which we call elements. But this is of course only an hypothesis. So long as we accept it as such it is of the utmost service to us; whenever we erect it into a dogma it ceases to become an aid to the investigation of nature, and begins to exercise a tyranny over us.

An amusing and instructive instance of the narrowing and deadening effect of accepting an hypothesis dogmatically is narrated in Prof. Bryce's recently-published book on Trans-Caucasia. Prof. Bryce accomplished the ascent of Mount Ararat: tradition says that no one has ever been to the summit of this mountain; the inhabitants of the neighbouring country have formed this saying into a dogma which teaches that no one can ascend to the top of Ararat. When Prof. Bryce told the Archimandrite of the district that he had been to the summit the old man only smiled a sweet, sad, pitying smile, and said it was impossible.

The more modern history of the chemical elements warns us against dogmatising concerning the nature of these bodies. Potash and soda were classed among the elements until the year 1807. Water was for ages regarded as elementary; Cavendish first taught us that the long-cherished tradition was false.

The problem of the nature of the elements is one which requires the use of the imagination; it is a problem in endeavouring to solve which we are very ready to give the reins to this faculty, or rather to allow the lower power of fancy to usurp the place of the more divine imagination—and thus we run riot. The naturalist who approaches the investigation presented by the chemical elements had need to learn the scientific use of the imagination.

Many years ago an hypothesis was started by Prout to the effect that the elements are all compounds of hydrogen, that hydrogen is the primary form of matter, and that the molecule of each element is composed of a varying number of atoms of hydrogen. If this hypothesis were correct the combining or atomic weights of the elements would be simple multiples of the combining or atomic weight of hydrogen, *i.e.*, multiples of 1. The experiments of Dumas lent support to the hypothesis of Prout, but the later and more exact researches of Stas negatived the idea.

Stas showed, in a wonderful series of investigations, that the atomic weights of the elements are not simple multiples of 1, nor of $\frac{1}{2}$, as Dumas had supposed, but that they are fractional numbers. Stas further showed that the same number, as representing the atomic weight of a given element, is obtained by different processes of investigation.

But may not Prout's hypothesis have some truth underlying it? Are the elements really elementary? Stas's researches do not answer this question. We may put the general question in two forms. Are the elements compounds, in varying proportions, of a few simple bodies? or, Are the elements compounds, in varying proportions, of *one* primary form of matter? Let us look at these questions in succession—and first we may frame the hypothesis that the elements are compounds of a few simple bodies.

In order to learn what are the general properties exhibited by a series of bodies all of which are compounds,

[1] A paper read before the Owens College Chemical Society.

in varying proportions, of a few simple bodies, let us consider one of the homologous series of hydrocarbons; say the marsh-gas series. CH_4, C_2H_6, C_3H_8, C_4H_{10}, C_5H_{12}, C_6H_{14}, &c., &c.; generally C_nH_{2n+2}. The members of this series are all compounds, in varying proportions, of carbon and hydrogen; each differs from the preceding by an increment of CH_2. The difference between the molecular weights (the weights of two vols.) of the members of the series is 14. The physical properties of the series show a gradation from the first upwards. The first is gaseous at ordinary temperatures: as we ascend the series we have liquids of gradually-diminishing liquidity, then solids, the melting-points of which gradually increase. The chemical properties of the series, so far as these have been investigated, also exhibit a regular gradation. If we divide the specific heats of these compounds by their molecular weights, we do not obtain the same number for each—in other words, the molecular heat of the members of this series varies: this is a point of some importance. The specific volumes —products obtained by dividing molecular weights by specific gravities determined at that point at which each vapour exerts the same tension, that is, at the boiling points of the liquids—of the members of this series differ by 22. A simple relation of some kind most probably exists between the densities of the members of this series, between the actions exerted by these bodies on light, &c., &c.

Take now a group of allied elements:—Oxygen (16), sulphur (32), selenium (79·5), tellurium (128). The atomic weights—or the molecular weights, whichever form is preferred—of the higher members of the series are multiples of the atomic weight of the first: $16 \times 2 = 32$, $16 \times 5 = 80$; $16 \times 8 = 128$. Oxygen is a gas, except under conditions of great pressure; sulphur melts at about 115°, selenium at about 100°, but a modification at 215°; tellurium at 450° C. There is a gradation in the general chemical nature of the four elements. There is a simple relation between the specific volumes of these four elements in the solid state; this relation is expressed by the numbers 1 : 3 : 3 : 4. The atomic heats of the three last-named substances are the same; the atomic heat of solid oxygen, as deduced from observations carried out on compounds, is rather less than the number representing the atomic heats of sulphur, selenium, and tellurium. I might adduce other series of elements, let one suffice:—

	Lithium.	Sodium.	Potassium.	Potassium.	Rubidium.	Cæsium.
Atomic weight =	7	23	39·1	39·1	85·4	133
Mean ,, =	—	23·05	—	—	86·05	—

The atomic weight of the second member of each subsection of this series is almost exactly the mean of the atomic weights of the first and third; in each case the number representing the atomic weight of the middle element is a very little less than the mean of the atomic weights of the elements at the extremes of the series. The specific volumes of the metals lithium, sodium, potassium, and rubidium (the specific gravity of cæsium is unknown) are respectively, 11·9, 23·7, 45·1, and 56·2; these numbers are nearly in the proportion of 1 : 2 : 4 : 5; there is a regular gradation, therefore, in the specific volumes of the members of the present series. The physical and chemical properties of the series show gradations, which, so far as they have been examined, appear capable of tolerably simple generalisation. The atomic heat of the five metals is represented by a (practically) constant number. Now most of these facts are quite in keeping with the hypothesis that the elements which I have noticed are compounds of simpler forms; the properties of the compounds of the homologous series, C_nH_{2n+2}, are in very many respects analogous with the properties of the two series of so-called elements to which I have drawn attention. There is, however, one important difference between a certain physical property of the homologous series and the same property as exhibited in the elementary series—the atomic or molecular heats of the elements are, with few exceptions, the same; the numbers expressing the molecular heats of the members of the homologous hydrocarbon series are multiples of each other.

"It seems a general law," says Berthelot, "that the molecular heats of polymerised radicles are multiples of each other, whereas the molecular heats of the elements are, with very few exceptions, identical." The apparent exceptions among the elements, we have good reason to believe, will be found to obey the rule when more exact investigations have been carried out. This difference between the molecular heats of the elements and the molecular heats of series of homologous hydrocarbons lessens the probability of the elements being really compounds, in varying proportions, of a few simple bodies; or at any rate, it leads us to believe that, as Berthelot says, the phenomena attending the decomposition of the elements—supposing them to be really compounds—must be different from the phenomena attending the decomposition of those bodies which we know to be compounds. Nevertheless, I think that too much weight may be attached to this fact of differences in molecular heats. We do know of many compound gases, gases in the formation of which a very considerable amount of condensation occurs, but which have almost identical molecular heats. We have whole series of similarly constituted groups of compounds having the same molecular heats, *i.e.*, provided we accept the ordinary formulæ for solid compounds as molecular formulæ. So that the mere fact that the elements have the same molecular heats need not, I think, be a bar in the way of regarding these bodies as compounds, provided we have other evidence pointing in that direction.

But I must now briefly consider the second form under which the general question of the nature of the elements presents itself, viz., are the elements compounds, in varying proportions, of *one* primary form of matter? As a matter of fact we know of compounds in varying proportions of the same elements; we know also of compounds in varying proportions of one and the same element. The facts which have been amassed concerning allotropy and isomerism must be of service in any attempt which may be made to answer the question we are now to consider.

It is generally possible to trace a simple relation between the specific volumes $\left(\frac{\text{mol. wt.}}{\text{Sp. Gr.}}\right)$ of the various members of a group of elements; we have seen that such a relation exists in the two groups already considered, viz., the oxygen group and the potassium group. But it is stated by F. W. Clarke, of Cincinnati, who has partially investigated this subject of specific volumes, that so far as experiment has gone, no simple relation can be traced between the specific volumes of allotropic modifications of one and the same element. This statement appears to me to assume an amount of knowledge which we really do not possess. Clarke finds for the specific volume of ordinary sulphur the numbers 10·4 and 15·6; for prismatic sulphur he finds a number varying from 16·3 to 16·7; there is no simple relation between this number and either of the former. But he has assumed that the atomic weight of each allotrope is the same, and we have no data warranting such an assumption; the knowledge which we do possess points rather to an opposite conclusion. I think I am right in saying that in the case of oxygen and ozone we do possess some accurate knowledge of the (relative) molecular weights of two allotropes; these molecular weights are different; hence, probably, the atomic weights of the allotropes are also different.

M. M. PATTISON MUIR

(*To be continued.*)

ON THE NATURE OF VIBRATORY MOTIONS[1]

II.

Blackburn's Double Pendulum.

EXPERIMENT 7.—Let us return to our sand-pendulum. We have examined the vibrations of a single pendulum, let us now examine the vibrations of a double pendulum, giving two vibrations at once. The little copper ring *r*, in Fig. 7, on the cord of our pendulum, will slip up and down, and by moving it in either direction we can combine two pendulums in one. Slide it one quarter way up the cord, and the double cord will be drawn together below the ring. Now, if we pull the bob to the right or left, we can make it swing from the copper ring just as if this point were a new place of support for a new pendulum. As it swings, you observe that the two cords above the ring are at rest. But the upper pendulum can also be made to swing forward and backward, and then we shall have two pendulums combined. Let us try this and see what will be the result.

Just here we shall find it more convenient to use the metric measure, as it is much more simple and easy to remember than the common measure of feet and inches. If you have no metric measure you had best buy one, or make one. Get a wooden rod just $39\frac{37}{100}$ inches long, and divide this length into 100 parts. To assist you in this you may remember that 1 inch is equal to $25\frac{4}{10}$ millimetres. Ten millimetres make a centimetre, and 100 centimetres make a metre.

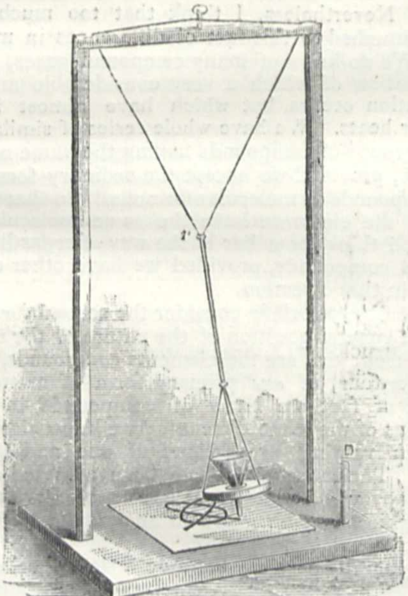


FIG. 7.

Now slide the ring *r*, Fig. 7, up the cords till it is 25 centimetres from the middle of the thickness of the bob. Then make it exactly 100 centimetres from the under side of the cross-bar to the middle of the thickness of the bob, by turning the violin-key on the top of the apparatus.

At D, Fig. 7, is a small post. This post is set up anywhere on a line drawn from the centre of the platform, and making an angle of 45° with a line drawn from one upright to the other. Fasten a bit of thread to the string on the bob that is nearest to the post, and draw the bob toward the post and fasten it there. When the bob is perfectly still fill the funnel with sand, and then hold a lighted match under the thread. The thread will burn, and the bob will start off on its journey. Now, in place of swinging in a straight line, it follows a curve, and the sand traces this figure over and over.

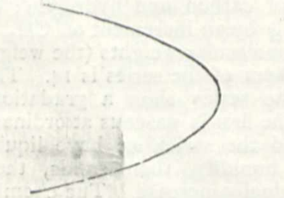


FIG. 8.

Here we have a most singular result, and we may well pause and study it out. You can readily see that we have here two pendulums. One-quarter of the pendulum swings from the copper ring, and, at the same time, the whole pendulum swings from the cross-bar. The bob cannot move in two directions at the same time, so it makes a compromise and follows a new path that is made up of the two directions.

The most important fact that has been discovered in relation to the movements of vibrating pendulums is that the times of their vibrations vary as the square roots of their lengths. The short pendulum above the ring is 25 centimetres long, or one-quarter of the length of the longer pendulum, and, according to this rule, it moves twice as fast. The two pendulums swing, one 25 centimetres and the other 100 centimetres long, yet one really moves twice as fast as the other. While the long pendulum is making one vibration the short one makes two. The times of their vibrations, therefore, stand as 1 is to 2, or, expressed in another way, 1 : 2.

Experiment 8.—Let us try other proportions and see what the double pendulum will trace. Suppose we wish one pendulum to make 2 vibrations while the other makes 3. Still keeping the middle of the bob at 100 centimetres from the cross-bar, let us see where the ring must be placed. The square of 2 is 4, and the square of 3 is 9. Hence the two pendulums of the double pendulum must have lengths as 4 is to 9. But the longer pendulum is always 1,000 millimetres. Hence the shorter pendulum will be found by the proportion 9 : 4 : : 1,000 : 444·4 millimetres. Therefore we must slide the ring up the cord till it is 444·4 millimetres above the middle of the thickness of the bob.

Fasten the bob to the post as before, fill it with sand, and burn the thread, and the swinging bob will make this singular figure (Fig. 9).

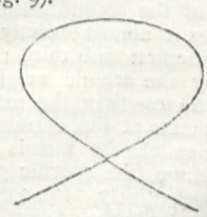


FIG. 9.

Experiment 9.—From these directions you can go on and try all the simple ratios, such as 3 : 4, 4 : 5, 5 : 6, 6 : 7, 7 : 8, and 8 : 9. In each case raise the two figures to their squares, then multiply the larger number by 1,000, and divide the product by the smaller number; the quotient will give you the length of the smaller pendulum in millimetres. Thus the length for rates of vibration, as 3 is to 4, is found as follows: $3 \times 3 = 9$, $4 \times 4 = 16$, and $\frac{9 \times 1{,}000}{16} = 562{\cdot}5$ millimetres.

The table (Fig. 10) gives, in the first and second columns, the rates of vibration, and in the third and

[1] From a forthcoming work on "Sound: a Series of Simple, Entertaining, and Inexpensive Experiments in the Phenomena of Sound, for the Use of Students of every Age." By Alfred Marshall Mayer, Professor of Physics in the Stevens Institute of Technology. Communicated by the Author. (Continued from p. 574.)

fourth columns the corresponding lengths of the longer and shorter pendulums. Opposite these lengths are the figures which these double pendulums trace. In the sixth column are the names of the musical intervals formed by two notes, which are made by numbers of sonorous vibrations, bearing to each other the ratios given in the first and second columns.

	Mm.	Mm.	
1 : 2 =	1,000 :	250·0………	Octave.
2 : 3 =	1,000 :	444·4………	Fifth.
3 : 4 =	1,000 :	562·5………	Fourth.
4 : 5 =	1,000 :	640·0…….	Major Third.
5 : 6 =	1,000 :	694·4………	Minor Third.
6 : 7 =	1,000 :	734·6………	Sub-Minor Third.
7 : 8 =	1,000 :	766·6………	Super Second.
8 : 9 =	1,000 :	790·1………	Second.

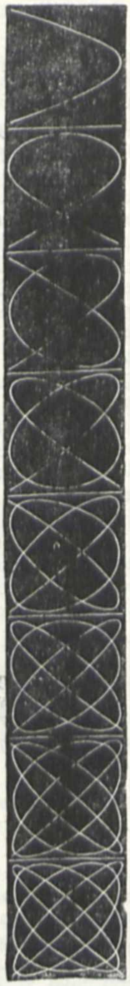


FIG. 10.

Prof. Kundt's Experiment, made with a Whistle and a Lamp Chimney, showing that, as in Wind Instruments, a vibrating Column of Air may originate Sonorous Vibrations.

Experiment 10.—The chimneys of student-lamps have a fashion of breaking just at the thin, narrow part near the bottom. Such a broken chimney is very useful in our experiments. At A, in Fig. 11, is such a broken chimney, closed at the broken end with wax. A cork is fitted to the other end of the chimney, and has a hole bored through its centre. In this hole is inserted part of a common wooden whistle. At B is an exact representation of such a whistle, and the cross-line at C shows where it is to be cut in two. Only the upper part is used, and this is tightly fitted into the cork.

Inside the tube is a small quantity of very fine precipitated silica, probably the lightest powder known. Hold the tube in a horizontal position and blow the whistle. The silica powder springs up into groups of thin vertical plates, separated by spots of powder at rest, as in the figure. This is a very beautiful and striking experiment.

Experiment 11.—The following experiment shows that the sound is caused by the vibrations of the column of air in the tube and whistle, and not by the vibrations of these solid bodies. Grasp the tube and whistle tightly in the hands. These bodies are thus prevented from vibrating, yet the sound remains the same.

The breath driven through the mouth of the whistle strikes on the sharp edge of the opening at the side of the whistle, and sets up a flutter or vibration of air. The air within the glass tube now takes part in the vibrations, the light silica powder vibrates with it, and makes the vibrations visible.

To exhibit this experiment before a number of people, lay the tube carefully on the water-lantern before the heliostat, and throw a projection of the tube and the powder on the screen. When the whistle is sounded, all in the room can see the fine powder leaping up in the tube into thin, upright plates.

Experiment 12.—Mr. Geyer has made the following

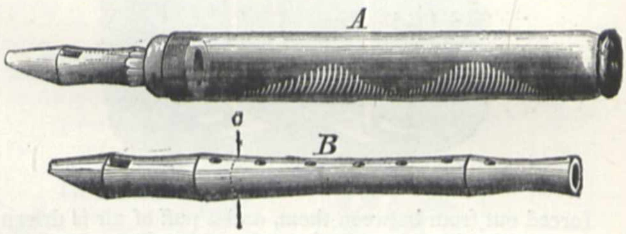


FIG. 11.

pleasing modification of this experiment:—Take a glass tube about 2 feet (61 centimetres) long and ¾ inch (19 millimetres) diameter. One end of this tube is stopped with a cork; then some silica is poured into it. The other end is placed in the mouth. Singing into the tube, a note is soon struck which causes the silica to raise itself in groups of vertical plates, separated by places where the powder is at rest, the number of these groups and their positions in the tube changing with the note sung.

We have now seen how solids, like steel or brass, may vibrate and give a sound. We have heard a musical sound from vibrating water, and these last experiments prove that a gas, like air, may also vibrate and give a sound. In the next chapter you will find experiments which show how these vibrations move through solids, through liquids, and through the air.

On the Interference of Sonorous Vibrations and on the Beats of Sound.

Experiment 13.—Cut out two small triangles of copper foil or tinsel, of the same size, and with wax fasten one on the end of each of the prongs of a tuning-fork. Put the fork in the wooden block and set up the guide. Prepare a strip of smoked glass, and then make the fork vibrate and slide the glass under it, and get two traces, one from each prong.

Holding the glass up to the light you will see the double trace, as shown in Fig. 12. You observe that the

FIG. 12.

wavy lines move apart and then draw together. This shows us that the two prongs, in vibrating, do not move in the same direction at the same time, but always in opposite directions. They swing toward each other, then away from each other.

Experiment 14.—What is the effect of this movement of the prongs of the fork on the air? A simple experiment will answer this question.

Place three lighted candles on the table at A, B, and C (Fig. 13). Hold the hands upright, with the space between the palms opposite A, while the backs of the hands face the candles B and C. Now move the hands near each other, then separate them, and make these motions steadily and not too quickly. You thus repeat the motions of the prongs of the fork. While vibrating the hands observe attentively the flames of the candles. When the hands are coming nearer each other, the air is

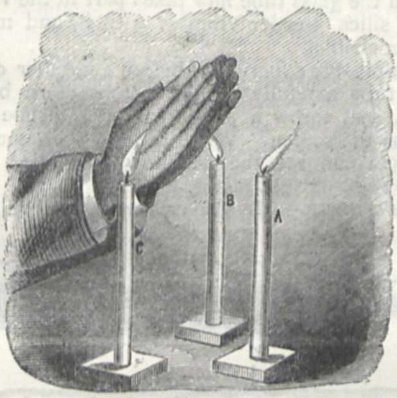


FIG. 13.

forced out from between them, and a puff of air is driven against the flame A, as is shown by its bending away from the hands. But, during the above movement, the backs of the hands have drawn the flame toward them, as shown in Fig. 13. When the hands are separating, the air rushes in between them, and the flame A is drawn toward the hands by this motion of the air, while at the same time the flames at B and C are driven away from the backs of the hands. From this experiment it is seen that the space between the prongs and the faces of the prongs

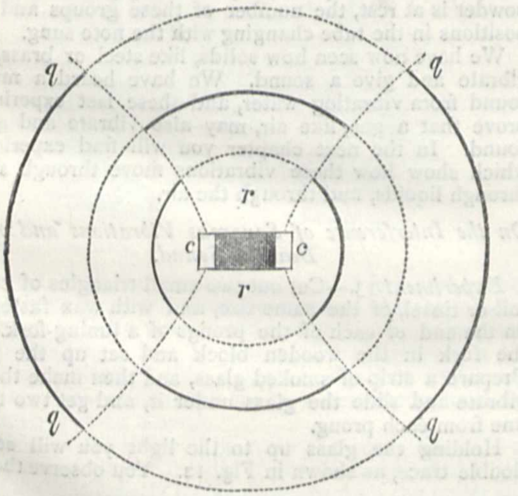


FIG. 14.

of a fork are, at the same instant, always acting oppositely on the air.

This will be made clearer by the study of the diagram, Fig. 14.

This figure supposes the student looking down on the tops of the prongs of the fork. Imagine the prongs swinging away from each other in their vibration. Then the action of the faces *c* and *c* on the air is to condense it, and this condensation tends to spread all around the fork. But, by the same movement, the space *r r* between the prongs is enlarged, and hence a rarefaction is made there. This rarefaction also spreads all around the fork. But, as the condensations produced at *c* and *c* and the rarefaction at *r* and *r* spread with the same velocity, it follows that they must meet along the dotted lines *q*, *q*, *q*, *q*, drawn from the edges of the fork outwards. The black ¼-circle lines around the fork in Fig. 14 represent the middle of the condensed shells of air, while the dotted ¼-circle lines stand for the middle of the rarefied shells of air.

Now what must happen along these dotted lines, or, rather, surfaces? Evidently there is a struggle here between the condensations and the rarefactions. The former tend to make the molecules of air go nearer together, the latter try to separate them; but, as these actions are equal, and as the air is pulled in opposite directions at the same time, it remains at rest—does not vibrate. Therefore, along the surfaces *q*, *q*, *q*, *q*, there is silence. When the prongs vibrate toward each other they make the reverse actions on the air; that is, rarefactions are now sent out from *c* and *c*, while condensations are sent from *r* and *r*, but the same effect of silence along *q*, *q*, *q*, *q* is produced.

Experiment 15.—That this is so is readily proved by the following simple experiment:—Vibrate the fork and hold it upright near the ear. Now slowly turn it round. During one revolution of the fork on its foot you will perceive that the sound goes through four changes. Four times it was loud, and four times it was almost, if not quite gone. Twirl the fork before the ear of a companion; he will tell you when it makes the loudest sound and when it becomes silent. You will find that when it is loudest the faces *c*, *c* of the prongs, or the spaces *r*, *r* between them, are facing his ear; and when he tells you that there is silence you will find that the edges of the fork, that is, the planes *q*, *q*, *q*, *q*, are toward his ear.

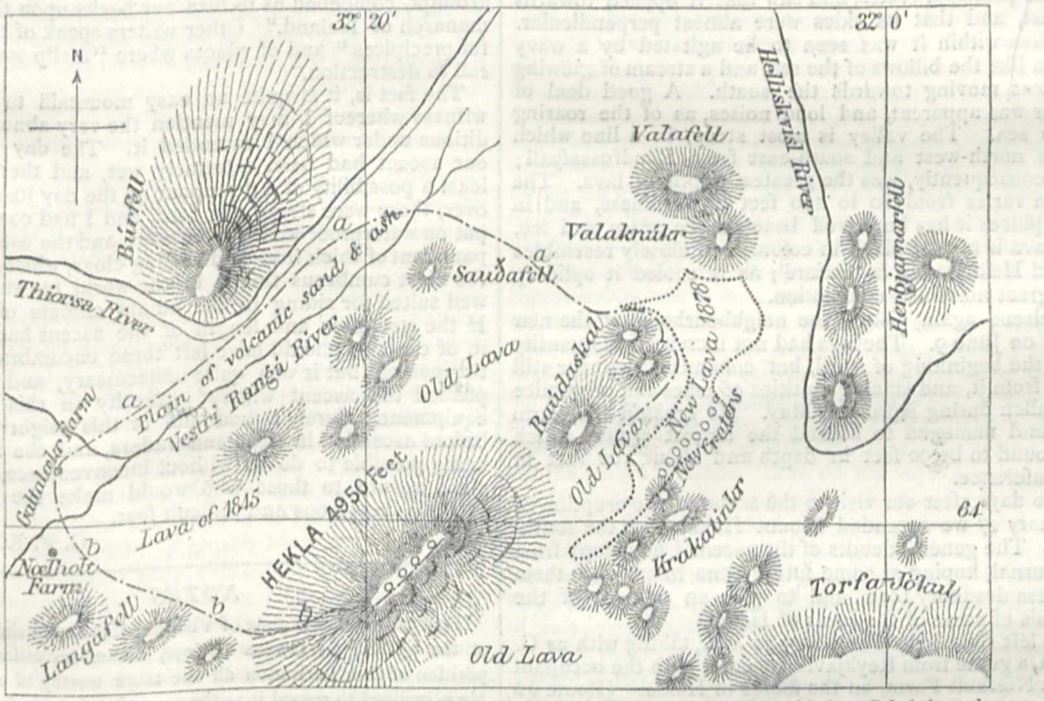
(*To be continued.*)

ON AN ASCENT OF MOUNT HEKLA, AND ON THE ERUPTION OF FEBRUARY 27, 1878

ON February 27 last severe earthquakes were felt throughout the south-west portion of Iceland, particularly in the districts of Land, Rangarollir, Hreppa, and Fljotschlith, which are situated immediately to the south and south-west of Mount Hekla. Between 8 and 9 P.M. an intense illumination of the sky, at first believed to be actual fire, was seen to the south-east. This was found to be due to the reflection by clouds of the light emitted by molten lava within a subsidiary crater, or *bocca del fuoco*, as the Italians would call it, of Hekla. On the following day dense columns of smoke ascended from the crater, and quantities of volcanic ashes fell in the districts of Hreppa and Biskupstundur. The light was seen at Reykjavik, nearly seventy miles distant, and there appeared to be two vents of fire.

One month after the eruption Prof. Tómas Hallgrimson visited the district and endeavoured to discover the exact position of the new crater. He found it in the Raúdaskal Valley, about four miles to the north-east of Hekla, and in connection with one of its outlying spurs. The chief crater was observed to be near the northern base of Krakatinkr, and a good deal of new lava was heaped around it. Herr Nielsens, a merchant of Eyrabakki, on the southern coast of Iceland, visited the scene of the eruption about the same time, and by ascending Krakatinkr he was able to look down into the new crater. He also determined its position, and traced the course of the new lava streams. The map which is here reproduced (for which I am indebted to Sjera Gudmundr Jonsson, the priest of Stóruvellir, a hamlet near to Hekla) is a copy of Nielsens' sketch made on the spot.

Upwards of a month ago (August 21) I visited the scene of the eruption, in company with three friends. Two guides accompanied us, and we took a relay of ponies in case of accident or fatigue. We left the Galtalœkr farm (see the map, route *a a*) at 7.30 A.M., crossed a small streamlet, and soon came upon a growth of dwarf birch-trees from one to two feet in height. Here we put up a covey of very tame ptarmigan. On emerging from the underwood we entered a long level plain of volcanic sand and ash, extending between the river Thiorsa and the smaller stream called Vestri-Rángá. We cantered over the plain for about ten miles, turning aside for a moment to look at the falls of the Thiorsa, at the southern base of Búrfell. The substance of the plain is black volcanic sand and ash, with occasional white, grey, and red patches of pumice. At 9.15 A.M. we found ourselves near the termination of the Vestri-Rángá, and, bearing to the south-east, we forded the stream, and almost immediately afterwards came upon fields of volcanic ash and lava. The ground now became very rough, masses of lava were strewn in all directions, and there was of course no track. We passed several cones of ashes emitted by extinct craters, and presently saw in front of us Raúdaskal—the red mountain—a subsidiary cone probably thrown up in 1554. We wound along the Raudaskal valley, which is between six and seven miles in length and nearly two miles broad, passing by the base of several large cinder-cones. The new lava of 1878 was soon sighted, and we picked our way for about three miles between the edge of the field and the sloping sides of the cinder cones. By the time we had ridden some twenty-three miles from Galtalœkr we found ourselves at the edge of a field of old lava, contiguous to the lava of 1878, and in sight of the largest of the new craters. The summit of Hekla was on our right, about four miles distant, and Krakatinkr was nearly facing us to the south. Here we left the ponies, tied head and tail together, to prevent straying during our absence. The only possible way to get nearer to the new crater was to clamber over the old



Map of Mount Hekla showing position of the new craters. Route *a a*, from Galtalœkr to the new craters. Route *b b*, from Galtalœkr to the summit of Hekla. The dotted line between Valaknukr and Krakatinkr shows the position and extent of the lava field of 1878.

Scale $\frac{1}{240,000}$. ¼ ½ 1 × 2 Miles Danish.

bed of lava, which, although very rough and jagged, was not difficult to cross, on account of its covering of moss. At the edge of this bed we came upon a small tract of old snow, covered with volcanic ash to the depth of about eight inches. Then we reached the new lava and saw the largest cone of the new craters immediately in front of us, and about half-a-mile distant. The new lava was more rough and cindery, at least at the surface, than any I have ever seen around Etna or Vesuvius. Its surface was extremely jagged, and it was broken into ridges, and crests, and sharp pinnacles, which yielded uncertain support to the foot or hand. Hence it was both difficult and dangerous to cross, and we could only climb over a few dozen yards of it. Standing upon its surface we could see the cone of the largest of the new craters emitting small quantities of vapour and incrusted with red and yellow substances. The lava field extended both to our right and left, and in some places it was giving off vapour. The edge of the field along which we travelled was about twenty feet in depth, but in some places it was piled to a much greater height. The lava was very close and compact some distance from the exterior; it was cracked and split in all directions. White incrustations of salt (*not* chloride of ammonium, which is common in some lavas) were often noticed at the points of fracture; also brilliant red and yellow incrustations, which are often mistaken for sulphur, but which in the case of this lava, at least, I have proved to be *sesquichloride of iron*. In some parts of the lava these incrustations covered many square yards, while fumes of hydrochloric acid were freely emitted in their vicinity. The sesquichloride when removed from the lava rapidly absorbed moisture from the air and formed an intensely acid solution. We left the neighbourhood of the new crater at 2.30 P.M., rested at 4 P.M. on the banks of the Vestri-Rángá, and reached Galtalœkr at 6.15 P.M., having left it eleven hours before, and travelled over nearly fifty miles of volcanic country.

Two short accounts of the eruption have been published in Icelandic, the one by Prof. Hallgrimson, the other by Herr Nielsens. These have been translated for me by Herr Matthias Jockumsson, of Reykjavik, to whom I beg to express my acknowledgments. According to Hallgrimson there are fourteen small craters situated in a line passing from west-south-west to east-north-east, which line, if prolonged, would pass through the centre of the craters on the summit of Hekla. The distance between the extreme craters of February 27 is about 6,000 feet. The lava flowed more than a mile to the south of the largest of the new craters, but the main stream flowed to the north and north-east, and nearly reached the Mountain Valaknúkr.

Nielsens approached the scene of the eruption, a month after its commencement, from the north-west, and passing between Valafell and Valaknukr, he went due south to Krakatinkr, along the eastern edge of the new lava. From the summit of Krakatinkr he looked down into the principal crater, and saw that it opened towards the east, and that its sides were almost perpendicular. The lava within it was seen to be agitated by a wavy motion like the billows of the sea, and a stream of glowing lava was moving towards the south. A good deal of vapour was apparent, and loud noises, as of the roaring of the sea. The valley is most steep, in a line which passes north-west and south-east from Raudfossafyall; here, consequently, was the greatest depth of lava. The stream varies from 10 to 100 feet in thickness, and in some places it has burrowed beneath the snow and ice. The lava is almost black in colour, and closely resembles the old Hekla lavas in texture; as it cooled it split up with great noise and commotion.

Nielsens again visited the neighbourhood of the new crater on June 9. The lava had not increased in quantity since the beginning of April, but columns of vapour still arose from it, and small quantities of ashes and of pumice had fallen during April and May. He crossed the warm lava and managed to ascend the largest crater, which was found to be 90 feet in depth and about 100 feet in circumference.

Two days after our visit to the scene of the eruption of February 27 we ascended Mount Hekla from the south-west. The general details of the ascent I now copy from my journal, hoping at some future time to produce them in a less desultory form, and to give an account of the analysis of some of the lavas of Hekla.

We left Galtalœkr Farm at 9.40 A.M., taking with us G. Zöega, a guide from Reykjavik, together with the occupant of the Nœfholt Farm, on the flanks of Hekla. (Route *b b* on the map). Having crossed the Vestri-Rángá, we proceeded nearly due south, passed the Nœfholt Farm, near which we came upon the lava of 1845; and then passed over some very rough lava-strewn ground covered with volcanic ash, which concealed holes into which the ponies sometimes stumbled and fell. The lava of 1845 is covered with the same moss which we noticed on the old lava near the crater of 1878, which causes it to look much older. When the ascent became greater, we left the ponies. Distance to foot of steep incline about seven miles from Galtalœkr. Followed the southern boundary of the lava-field of 1845, until we reached a steep incline which we ascended. Crossed a small portion of the old lava field, then a tract covered with volcanic ashes, and finally found ourselves at the bottom of a steep slope covered with snow, beneath which water was heard rushing downwards. The ascent of this slope without alpenstocks was not easy. Several other snow slopes were crossed, and we then found ourselves near the crater of 1845—the most westerly of the four craters on the summit of Hekla. Above this we saw a crater with a red smoking mound within it; then in succession the third and fourth craters, and beyond the most easterly crater a nearly level snow-covered waste full of lava blocks. From the most easterly extremity of this, which was reached at 2.30 P.M., we looked down upon the principal crater of 1878. The summit of Hekla is covered with much ash, sand, and red pumice, together with lavas of every degree of compactness, from the most vesicular up to obsidian. The descent over the snow-slopes was troublesome, on account of their steepness and the slipperiness of the snow, but we regained the spot at which we had left the ponies at 5 P.M.

Hekla was ascended for the first time in the year 1770. The difficulties of the ascent have been much exaggerated subsequently. Many travellers have made no attempt to scale the mountain. Even the "American in Iceland," who was in the neighbourhood of Hekla only three years ago, asserts that "the obstacles, real and imaginary, stated to be in the way, such as tortuous and difficult paths, swollen rivers, depth of snow, treacherous bogs, and the evident indisposition of the guides, perhaps from superstitious fears, to make the attempt, compelled us to turn our backs upon this snowy monarch of Iceland." Other writers speak of the "fearful precipices" and of places where "a slip would be to roll to destruction."

The fact is, it is quite an easy mountain to climb, in witness whereof I may mention the very abnormal conditions under which I ascended it. The day preceding our ascent had been extremely wet, and there was at least a possibility of a downpour on the day itself; moreover, there were streams to ford, and I had consequently put on waterproof wading stockings, and the usual accompaniment of thick iron-clad wading clogs, which, although the most cumbrous things in the world to walk in, are well suited for riding in the humid climate of Iceland. If the steepness and length of the ascent had required it, of course I should have left these encumbrances with the ponies, but it was quite unnecessary, and I accomplished the ascent without difficulty in this unwieldy equipment. Surely a mountain of this height was never before ascended in clogs and waders, and the fact of its being possible to do so without inconvenience, is a sufficient answer to those who would make the ascent of Hekla a dangerous and difficult feat.

G. F. RODWELL

NOTES

THE moderation in tone of Viscount Cardwell's short address at the opening of Owens College, makes his estimate of the position of that institution all the more worthy of acceptance. He is inclined to regard it as the most singular acquisition to the academical strength of the county since the middle ages; and we venture to think that one chief reason why it occupies so distinguished a position is the completeness, the all-roundness of the education which it furnishes. There, science and letters are on an equal footing, and it will only be when this is the case in all our educational institutions that the educational apparatus of the country will be thoroughly efficient. The fact that Owens College now administers funds exceeding 400,000*l.*, all obtained from private sources, is one proof that it fills a great want. We have on previous occasions spoken of its claims to be erected into a university. The tone of Lord Carnarvon's address at Saltaire, was in effect similar to that of Lord Cardwell; education is incomplete unless all our faculties have equally fair play.

ACCORDING to the Naples correspondent of the *Times*, Prof. Palmieri does not think there is any likelihood of a violent eruption of Vesuvius. The mountain has been in an eruptive state for two years; the cup is full, and must run over, but will probably do so quietly. The state of Vesuvius gives some interest to the project of the construction of a railway intended to conduct travellers from Naples to the margin of the crater. The scheme, proposed by a Neapolitan banker, has just been adopted.

According to the *Italie*, the waggons will be dragged by a rope. The length of the way will be only 840 metres, and the altitude reached 490 metres above the level of the sea. Each waggon will have only four seats, and four waggons, carrying sixteen passengers, will go up at the same time that four others loaded with sixteen persons will come down. Each waggon will be supplied with a patent brake for stopping instantly if the rope breaks.

THE death is announced, at Milan, of Signor Giulio Curioni, a distinguished chemist, metallurgist, and geologist, in his 82nd year.

MR. EDISON, the *Polytechnic Review* states, has made some experiments with a view to accomplishing the reading of the phonograph record by sight; but although a fundamental form exists for each articulated sound, he finds it very difficult to free the record from what might be called accidental influences; for so sensitive are these markings that the same sound uttered by different persons, or the manner in which it is spoken, the distance of the mouth from the instrument, the force with which it is spoken, or the speed with which the barrel is rotated, gives a different form of indentation. Vowel sounds appear to be but little affected by these variations as compared with consonants.

ABOUT 14,000 telephones, we learn from the *Polytechnic Review*, had been introduced into the United States up to the close of the year 1877, and the manufacturers are receiving orders at the rate of about a thousand a month.

WE learn from the Report of the British Association Committee on Erratic Blocks, presented by Rev. H. W. Crosskey, that the Committee were supplied with notes on boulders near Kendal by Mr. J. R. Dakyng. The most remarkable are those of the granite of Wastdale Crag, near Shap Wells, the distribution of which seems to show that they must have travelled over the high ground south of the granitic area, and not have followed the course of the present drainage. The general due south course of the boulders is shown by their distribution south of Kendal. They have been traced as far south as Milnthrops and occupy a narrow band of country whose long axis point, directly to the granite of Shap Fells. The most westerly are some near Hincaster, and a line drawn from the most westerly outcrop of granite on Shap Fells to these boulders bears south by west. The most easterly in this neighbourhood is in a field near Windy Hill, about two miles south-east of Kendal railway station, but one has been found high up on the side of Grayrigg Fell. Boulders of the dark compact altered rock that surrounds the granitic area are generally found along with the granite boulders. When the localities where granite boulders occur are marked on a map, the steady lineal north and south direction of their course is very striking. Boulders of the ordinary volcanic rocks of the Lake Mountains indicate other directions for the ice-flows. One of these may be seen two and a half miles out of Kendal, and east of the line of granite boulders. As the granitic area of Shap Fells is at the extreme east end of the volcanic rocks, this boulder must have crossed the line of flow along which the granite boulders travelled. Some new facts were reported by Mr. MacIntosh relative to the derivation of boulders already recorded, the existence of several large boulders previously unnoted, and by the extent to which Ireland has sent erratics into England. The report further contained descriptions of the position and character of many large boulders and groups of boulders in Leicestershire and Staffordshire.

IT is announced that a second session of the International Congress of Ethnographical Science which met under the patronage of the French government in July last at the Palace of the Trocadéro, will be held on October 10 next at the Palace of the Tuileries. This session is to be held in order that those who were unable to attend in Paris in July last may now have an opportunity of being present at the congress. In the course of a few days a programme will be published of the questions to which special attention is to be called. The committee of the Ethnographical Society of Paris which is organising the congress are especially desirous that England should be well represented on the occasion.

IN a recent issue of the *Indian Tea Gazette* we find some interesting notes of an attempted journey towards China, overland from Assam, extracted from the journal of Mr. C. H. Lepper, who, attracted to the subject, no doubt, by his previous residence in China and Japan, has always kept in view, since his arrival in Assam, the idea of taking advantage of the magnificent Brahmapootra as a road to within about 200 miles of the frontier of the province of Yünnan. His residence being only sixteen miles from Suddya, the furthest outpost on the north-east of India, he has had constant opportunities of making inquiries from the intervening peoples in regard to the distance, state of the tribes, &c., between our frontier and China. These proved so satisfactory in their results that early in 1876 he was induced to make an attempt to advance as far as possible in the direction of China with the object of obtaining more precise and practical information. Before the party left Suddya, the *mehla* or fair for the hill tribes had just been held, at which Chow Mang Ti, a chief of the Kamptis, acts as interpreter for that tribe and the Singfoos, who assemble there in considerable numbers. His brother, Chow Kun, accompanied Mr. Lepper as head of the Kampti guides, and in the course of conversation Chow Mang Ti stated that there would be no difficulty in getting through the intervening country to the Chinese border. Passing up the Brahmapootra, the party entered the Tenga Pani River through the Noa Dehing. They found the first three or four miles had a sandy bottom, with great quantities of the silkworm-feeding *Soom* tree on the banks, on which the forest soon became dense and the scenery beautiful. Near the first rapid is a pretty islet, named Shikar Mazeli, which, when seen from a point a little further up the stream, Mr. Lepper describes as "perfectly enchanting." After passing the village of Juna or Chuna, Mr. Lepper says "we soon came to a bend, having a very high forest facing us on a hill, containing banyan, valuable saul trees in great quantities, also uriam and soom trees; we noticed, too, the Bazal bamboo appeared again, bamboos up to within a short distance of this hill not having been seen on the river. The 'surat,' a horrid leaf, which, if touched, causes intense pain for days, is prevalent, also a kind of wild chestnut. Plantains, *toku pat*, *tora pat*, tree ferns, orchids, and other parasites, all help together with graceful patches of cane to make the picture perfect." Owing to numerous rapids progress was slow, and it was late on the fourth day when the party reached Shangkam, where they were kindly received by the Kamptis. After they had waited some time, Chow Mang Ti arrived from Suddya, and to their great disappointment assured them that it would be useless to attempt to proceed towards China at that time of the year, as the rainy season had set in. He, however, gave some information on pôints connected with the route to China. "It takes eight days," he said, "to reach Hobong, between which place and this you could get no supplies, and it would take you about sixteen days to get there. Hobong is a large town. Then it takes us eight days more to reach the Irrawaddy River, and would take you at least sixteen or eighteen days. It is between Hobong and the Irrawaddy that the ascent I told you of has to be made. A little past Hobong are the two hills of almost pure silver; . . . there is a great quantity of gold there too, which gives that little colony of ours the name of Kamp Thi, meaning gold country, by which name you call all of us, who are really Shans from Shan, a country lying nearer China, having a strip of Singfoo country lying between us and our colony of Kamp Thi. The Singfoos, again, lie between our Shan country and China. This Hobong route is better than the Hukong route, which leads to Burmah, as the Noa Dehing is not navigable now." As it was impossible to prosecute his projected journey without Chow Mang Ti's assistance, Mr. Lepper deemed it prudent to acknowledge the weight of the arguments which he advanced against making the attempt at that season, the more so as he was aware that the Government of India objected to Europeans crossing into the territories of the hill-tribes, and he had only obtained permission to cross the "inner line" on the ground that he desired to visit the Brahma Khund or Sacred Pool of Brahma. He accordingly descended the Tenga Pani River, and then proceeding up the Brahmapootra, visited the Sacred Pool, a spot which few living Europeans have ever reached.

FROM time to time we have given various examples of the progressive tendencies of the Japanese in many directions, and we are glad to be able to supplement them with the information that they are turning their attention to the dredging of their harbours. We learn from a Japanese contemporary that the ports of Niigata, Ishinomaki, and others are to be dredged and improved in such a way as to be most convenient for shipping. The Bay of Hachiro, in the province of Ugo, is to be dredged, at the estimated cost of a million *yen*. Mr. John Perry, engineer in the employ of the Public Works Department, and a number of students of the Survey Department were sent there in April in order to survey the bay, and their inspection will probably be completed in October. This work is the more important as there is no safe shelter for vessels in stormy weather between Hakodate and Tsuruga.

MR. EDWARD STANFORD has the following books and maps preparing for publication:—A fifth edition, greatly enlarged, of "The Physical Geology and Geography of Great Britain," by Alexander C. Ramsay, LL.D., F.R.S., Director-General of the Geological Surveys of the United Kingdom, with Geological Map printed in Colours, and numerous Illustrations; "Notes of a Tour in America from August 7 to November 17, 1877," by H. Hussey Vivian, M.P., F.G.S., with Map; "The Fairyland of Science: Chapters for Children," by Arabella B. Buckley, Illustrated; "Karamania; or, Life in Asiatic Turkey: a Journal of Travel in Cilicia (Pedias and Trachæa), Isauria, and Parts of Lycaonia and Cappadocia," by the Rev. E. J. Davis, M.A., English Episcopal Chaplain, Alexandria, Illustrated; "Manual of Physical, Historical, and Political Geography for Schools," by Keith Johnston, F.R.G.S., with numerous Maps and Illustrations; "Stanford's Compendium of Geography and Travel—Europe," Edited and Extended by Prof. A. Ramsay, F.R.S.; "Australasia," Edited and Extended by A. R. Wallace, F.R.G.S.; also in preparation, uniform with the last, "Asia," Edited and Extended by Col. Henry Yule, C.B., F.R.G.S., "North America," Edited and Extended by Prof. F. V. Hayden, of the United States Geological Survey; "Elementary Physics for Middle-Class Schools, with Experiments and Illustrations, to which are added Examination Questions on each Section," by John A. Bower, Science Master, Middle Class School, Cowper Street, London. Among Maps Mr. Stanford will publish an "Orographical Map of Asia," for Use in Schools and Colleges," Edited by Prof. Alexander C. Ramsay, F.R.S.; "Library Map of Japan," Compiled by E. Knipping; size, 4 feet 6 inches by 5 feet 6 inches; scale 17 miles to an inch; this is an entirely new and original map, compiled from the various large divisional Maps prepared by the Japanese, and corrected and extended from journeys made for the purpose by the author; Supplementary maps show the railways, chief roads, telegraphs, and lighthouses, and the new administrative divisions introduced in 1876; "Library Map of Africa," new edition, with the Results of all Recent Explorations carefully laid down; "School Map of Africa;" new edition; size, 50 inches by 58; scale 118 miles to an inch; "Library Map of South America;" new edition; "Library Map of Australia," in nine sheets; constructed from the most recent Official Documents furnished by the Surveyors-General, showing the Details of Recent Explorations, and including a supplementary Map of Tasmania; on the same scale; "General Map of Australia," with all the recent explorations, the roads, railways; and a "School Map of New Zealand."

MESSRS. E. AND F. N. SPON will publish during the forthcoming season:—"The Chemist's Pocket-Book," by Thos. Bayley; "The Power and Speed of Steam Vessels Calculated by Rules adapted for Vessels of all Types," by W. Bury, Mem. Inst. M.E.; "A Treatise on Bridge and Roof Construction," by Karl von Ritter, translated from the German by Lieut. Sankey, R.E.; "Applied Mechanics," by Prof. Calcott Reilly, M. Inst. C.E.; "Graphic Arithmetic," by G. S. Clarke, Instructor in Geometrical Drawing, Royal Indian Engineering College, Cooper's Hill; and a "Supplement to Spon's Dictionary of Engineering." M. Ch. du Moncel has published in the "Bibliothèque des Merveilles" a volume on "The Telephone, Microphone, and Phonograph," in which he describes in a popular form all the discoveries which for the last two years have astonished the world.

MESSRS. WILLIAMS AND NORGATE have sent us "Karl Ernst von Baer; eine biographische Skizze," by Dr. Ludwig Stieda, and "Karl Freidrich Gauss, Zwölf Kapitel aus seinem Leben," by Ludwig Hänselmann. Messrs. Longmans and Co. have published a fourth edition of Prof. Fleeming Jenkin's text-book on "Electricity and Magnetism.'

FROM America we have received the "Bibliography of North American Palæontology," by Dr. White and Prof. Alleyne Nicholson (Washington Government Printing Office), and "Annals of the Astronomical Observatory of Harvard College," vol. iv. part 2 (Cambridge, U.S.: Wilson and Son). From Australia we have Decade 5 of the "Prodromus of the Palæontology of Victoria," by Mr. F. McCoy, of the Victoria Geological Survey; "Meteorological Observations made at Adelaide Observatory during 1878," by Mr. Charles Todd; "Mineral Statistics of Victoria for 1877," and "Report of the Mining Surveyors for Victoria for Quarter ended March 31, 1878."

THE Chilian government has now established a meteorological service in all the ports that are connected by telegraph, and the daily observations are published in the government gazette at Santiago.

AN earthquake was felt at Pic-du-Midi Observatory on Wednesday, September 25, at 8h. 53m. in the morning. The snow was falling heavily. Heavy falls of snow have also been recorded in the Oberland, and communications with St. Gothard have been interrupted. Shortly after midnight on Friday the shock of an earthquake was felt at Osterath, in Germany.

FROM the 16th to the 18th of August the city of Cartago in Costa Rica, in Central America, was visited by five distinct shocks of earthquake. No particular damage was caused. What is to be noticed is the meteorological result: that the weather was changed, being attended by heavy showers that flooded the rivers. In all earthquake countries it is believed the weather is affected by such phenomena, and it is desirable that observations should be recorded, showing the influence of earthquakes on weather. It has been alleged that the Comrie earthquakes in Perthshire came on after rains and floods of the river.

PROF. KARL ARENDTS, of Munich, has been nominated corresponding member of the Lisbon Geographical Society, in acknowledgment of his merits in geography. Prof. Arendts is the editor of a new geographical serial, entitled "Deutsche Rundschau für Geographie und Statistik," published in monthly parts by Hartleben, of Vienna.

"VIH CHE SIN LOO" (magazine for the propagation of knowledge) is the title of a new monthly publication in the Chinese language, edited by Dr. Edkins, of Pekin.

SECCHI'S "Meteorologica Romana" has just been published by the Italian government. The last revision of proofs was made by Secchi's friend, Sig. Ferrari, death having prevented the great astronomer himself from finishing this last part of his work on the meteorology and climatology of the Eternal City.

THE twenty-third meeting of German and Austrian apiculturists took place at Greifswald on September 11-13, and was attended by over 700 persons.

THE International Agreement regarding the steps to be taken for protecting the wine-growing districts against phylloxera, was signed at Berne on September 17.

RECENT borings made in different parts of North Germany have proved beyond denial that the assertion made by several eminent geologists, that a mighty deposit of salt stretches from the Lüneburger Heide to the coast of the Baltic, is perfectly correct. The deposit begins near Lüneburg, passes underneath the Elbe, and extends right across the Grand Duchy of Mecklenburg. Another branch goes in the direction of the Duchy of Holstein, *viâ* Legeberg to Elmshorn and Heide. Borings made at Lübtheen, near Hagenow, by order of the Mecklenburg government, have now reached a depth of 456 metres, and the thickness of the deposit of salt now reaches 130 metres; the basis, however, is not yet reached.

THE *Palæontologist* is the name of a new journal of small size published in Cincinnati, devoted to the subject indicated by its title. It will be published from time to time as matter accumulates.

AMONG the many rare shells lately belonging to Dr. Marie, of New Caledonia, is a new Murex, which will be described by Mr. Bryce Wright in the next number of the *Proceedings* of the Malacological Society of Belgium, under the name of *Murex huttonæ*.

STUDENTS of physics will be glad to learn that Gauthier-Villars has just issued a complete collection of the papers of the lamented Léon Foucault. They are preceded by a notice from the pen of M. Lissajous.

RECENT numbers of *Globus* contains an account, by Dr. Schröder, of his second visit to Cyprus in 1873.

HERR GERHARD ROHLFS will start for a new exploring tour to Africa in the first week of October. He will be absent some eighteen months, and he begins his journey *viâ* Tripolis and Wadai.

IN the Barmsee, a small lake situated in the Bavarian mountains, near the villages of Mittenwald and Krün, not far from the Austrian frontier, numerous piles, dating from pre-historic lake-dwellings, have just been discovered by Herr Zapf. The massive piles are standing upright in the lake; some of them still show incisions and spikes on their surface, indicating the spots where they were united, or where planks rested upon them. They stand in rows parallel to the southern shore of the lake. Other rows run in a northerly direction, but in the latter the piles are smaller and stand close side by side, forming a sort of palisade. None of the piles now reach the surface of the water. The total length of these pile-dwellings is about 200 metres.

THE *Precurseur d'Anvers* publishes a letter from Zanzibar stating that the Belgian expedition had reached a place situated some distance in the interior. Owing to a misunderstanding, they were compelled to engage in conflict with the natives, and eventually had to seek refuge in flight. It is not yet known whether they succeeded in escaping or were murdered.

AN American Microscopical Congress met at Indianapolis on August 14-17, under the presidency of Dr. R. H. Ward. Nineteen papers in various departments of microscopical research were read. The congress resolved itself into a permanent organisation under the name of the American Society of Microscopists.

THE Christchurch (N.Z.) *Press* contains a description of a very complete physical, chemical, and metallurgical laboratory which has been established in connection with Canterbury College. It is well provided with the best apparatus, and is well fitted both for original research and for student work.

WE have received a neat and attractive little "Guide to the Upper Engadine," by Dr. J. Pernesch, published by Orell Füssli and Co., of Zurich. It contains useful and well-arranged information, with a small map and twenty-one well-executed illustrations.

WE have received the July number of the *Anales* of the Argentine Scientific Society, which, besides an account of the proceedings of the society, contains a narrative of journeys in Patagonia, by Ramon Lista, papers on the composition of the water of the Uruguay, by Mr. J. J. Kyle, on the Hemiptera Argentina, by Carlos Bery, and on the flora of Paraguay, by Domingo Parodi.

WE are asked to publish the following statement:—During the recent opening of the Grosvenor Gallery on Sunday, nearly 6,000 persons availed themselves of the privilege of visiting the exhibition. This success has encouraged the committee of the Sunday Society to arrange for the exhibition of a series of water colour drawings of Swiss life and scenery, sketched in Switzerland by Mr. William L. Thomas. The exhibition will be opened on the first three Sundays in October, from 2 to 5 P.M., at 33, New Bridge Street, Blackfriars, E.C. (the late offices of the London School Board), and the public will have free access to it by means of tickets, which will only be issued to those applying by letter, and sending stamped and addressed envelope to the Honorary Secretary, 19, Charing Cross, S.W. The Committee of the Sunday Society intend to continue these Sunday Art Exhibitions from time to time, until the Society's object is accomplished, and the public Museums, Art Galleries, and Libraries, are all opened on the people's weekly leisure day. The Society will be glad to receive pecuniary and other assistance to enable the Committee effectively to carry on these exhibitions.

THE separation of the Central Bureau of Meteorology of the French Government is an accomplished fact, and the officers will be located in an hotel in the Rue de Grenelle, St. Germain, where no readings can be taken, the inspection of the sky being as difficult as from the British Office in Victoria Street. These peculiarities have raised much sharp criticism, and it is not certain that this solution will be accepted by the French Legislative Assembly. It has been suggested that the Bureau should be located at the Trocadéro, or on the top of the Arc de Triomphe, where there are magnificent rooms in which offices could be established.

THE additions to the Zoological Society's Gardens during the past week include a Bonnet Monkey (*Macacus radiatus*) from India, presented by Mr. Frederick Carter; two White-crested Touracous (*Corythaix albocristata*) from South Africa, presented by Mr. W. Wormald; a Green Turtle (*Chelone viridis*) from the Island of Ascension, presented by Capt. J. Smith; a Tabuan

Parrakeet (*Pyrrhulopsis tabuan*), a Masked Parrakeet (*Pyrrhulopsis personata*) from the Fiji Islands, purchased; a Chestnut-backed Weaver-bird (*Hyphantornis castaneo-fusca*), four Rufous-necked Weaver-birds (*Hyphantornis textor*), two Grenadier Weaver-birds (*Euplectes oryx*), a Barbary Turtledove (*Turtur risorius*), a Vinaceous Turtledove (*Turtur vinaceus*) from West Africa, a Turquosine Parrakeet (*Euphema pulchella*) from New South Wales, two Undulated Grass Parrakeets (*Melopsittacus undulata*), seven Crested Ground Parrakeets (*Calopsitta novæ-hollandiæ*) from Australia, deposited; eight Mocassin Snakes (*Tropidonotus fasciatus*), born in the Gardens.

THE FIGURE AND SIZE OF THE EARTH[1]

III.

DURING the years 1816-52 a Russo-Scandinavian degree-measurement was carried out by Struve and Gen. Tenner, of unusual length and wonderful accuracy. It extended from Hammerfest in the north (70° 40′) to Ismail in the south (45° 20′), a length of 25° 20′. From this it followed that for latitude 56° 3′ 56″, the degree length is 57,137 toises, and in this was included a Swedish degree-measurement which gave 57,209 toises as the length of a degree in lat. 66° 20′ 12″. At this time extensions of earlier operations were undertaken in other countries; as in England with the result of $\frac{1}{280}$ for the earth's oblateness. Everest extended Lambton's East Indian degree-measurement, which at present has a length of over twenty-one degrees. Also a longitude measurement begun at an earlier period in Central Europe was recommenced and reaches now from Brest, Paris, Strassburg, Munich, to Vienna. With the assistance of the new data the amount of the earth's oblateness was again investigated, and now that there was no doubt of the accuracy of the measurements, it was shown distinctly that the earth was not an entirely regular elliptical spheroid, that the flattening did not pass regularly over the earth's surface. The theory was next propounded that the earth was an ellipsoid of three axes, but the proposition was not fully supported by the measurements.[2] A newly elaborated mathematical method, by which from the existing measurements, the figure of the earth could be obtained, and by which the remaining errors could be reduced to a minimum, was now applied by the great Bessel to the data before him, and according to these principles and on the basis of the best measurements, he obtained dimensions of the earth which still form the ground of all astronomical and geodetical calculations, and which are as follows:—He found for the equatorial radius of the earth 327207714 toises = 6377400 metres; for the polar radius 326113933 toises = 6356080 metres; and for the length of the earth's quadrant 10000855765 metres; while he gave the earth's oblateness as $\frac{1}{298 \cdot 153}$. He also deduced formulæ giving the length of a degree or of a parallel of latitude for any part of the earth; these formulæ will be found in most geodetic handbooks. New values for the dimensions of the earth were, ten years ago, deduced by Leverrier with the assistance of other measurements, but they differ very little from those of Bessel, and in almost all scientific works Bessel's constants are adopted. Thus, about the middle of the present century the solution of the original problem has been attained. And yet since that time there has unmistakably been an altogether unusual progress in all departments concerned in the solution of the problem. First of all, mechanical precision has in the last decades attained such perfection, that now astronomical observations, and especially the geographical determination of places, can be made with considerably greater accuracy than was possible a few decades ago. Moreover, these improvements have been accompanied with extraordinarily suitable new methods. The telegraphic determination of longitude, a method for the determination of the lengths of parallels, has above all, especially in the last ten years, attained such perfection, theoretically and practically, that the measurements carried out on this method are most accurate, and we may justly expect in the future most brilliant results from it. Altogether the problem is near a more substantial solution now than it ever was before, as there are so many well-equipped observatories at work, bound together by a network of the most accurate determination of longitude and latitude, extended over the surface of the earth, and the completion of which is yet going on. Of the greatest importance also in this connection is the more recent theory of measurement, according to which the points to be connected need not lie in one and the same meridian or parallel, but, on the contrary, are connected by an arc of a great circle lying in any direction—the geodetic line.

Thus have we seen how from the remotest times, among all the nations of the earth not only has the wish to obtain a knowledge of the form and size of our dwelling-place prevailed, but also the most earnest activity in attaining this knowledge of nature; how this has in an increasing degree gone hand in hand with the progress of the mathematical and physical sciences, having at last reached a worthy solution in our time; and we have the best reasons for believing that, closely following the progress of the sciences, our knowledge in this connection will soon reach the highest degree of certainty.

Remarks on Karl Maria Friederici's Paper, by Col. Clarke, R.E.

One feature of modern geodesy that has been left unnoticed by the writer of the foregoing paper is the application of the theory of probabilities, under the form of the "method of least squares," to the reduction of the observations. In any network of triangulation if it were required to obtain the distance apart of two of the extreme points, we should obtain varying results according to the set of triangles used in the calculation, and the question arises, What is the degree of credibility to be given to each result, or what the "probable error" of each? This implies, of course, that there is a superfluity of observations, that is, more than are absolutely necessary to fix all the points. If there were no superfluous observations there could be but one result obtained—an advantage in one respect (in saving calculation)—but then we should be wholly at sea as to the degree of trust to be placed in this one result. The theory of probabilities teaches us how to treat superfluous observations, and practically it leads to the calculation of a system of corrections to all the observations in order to bring them into harmony. Now there could be found an infinite variety of systems of corrections that would harmonise the observations, but the particular system we are led to by the method of least squares has this feature, that the sum of the squares of the corrections is an absolute minimum. In plain words, the triangulation is harmonised with the least possible alteration of the original observations as a whole.

These calculations, however, involve an enormous amount of labour, and one is compelled sometimes to relax the rigour of the theory, and accept some slight modifications. For example, in the triangulation of Great Britain and Ireland this method required the solution of an equation of 920 unknown quantities; this hopeless task was evaded by breaking up the triangulation into some fifteen or more parts.

The principal triangulation of India—unlike that which uniformly covers the face of this country—consists of chains of triangles running in a meridian direction crossed by several other chains perpendicular to them; as the longitudinal series from Kurrachee to Calcutta, and that from Bombay to Vizagapatam, the north-east longitudinal series, and others. The reduction of these chains of triangles by the method of least squares is a vast labour not yet completed.

The enormous mass of the Himalayan Mountains causes, or rather might theoretically be supposed to cause, an immense disturbance of the direction of gravity at the stations of the Indian arc amounting at the northern stations to 30″, with smaller amounts as the distances of stations southwards increases. Now it is very singular that, except at the very foot of the mountains, these discrepancies do not actually appear (to anything like that amount) in the arc itself or when it is used in the problem of the figure of the earth. This very remarkable circumstance has led to the hypothesis that the attraction of the superincumbent visible mass must be compensated for by a diminution of density in the strata underlying the mountains. Pendulum observations made for the purpose of elucidating this point have shown conclusively that the density of these underlying strata *is* actually less there than elsewhere. A compensation therefore takes place—but in a general way only; it cannot be shown that it is a mathematically exact compensation, consequently there is some residual doubt as to what really are the deflections of the vertical at the astronomical stations of the Indian arc.

We may supplement Karl Maria Friederici's account of how to calculate a meridian arc by a description of the method fol-

[1] Continued from p. 580.

[2] This is scarcely correct: the figure of three unequal axes agrees better with the observations than does the spheroid of revolution. But there is a necessity for this, and the ellipsoidal figure cannot be regarded as established.

lowed in calculating a portion of the English arc where proceeding from the Yorkshire coast between Redcar and Whitby (the survey station is Easington) it crosses the sea in a line to Saxaford in Shetland. At Easington astronomical observations gave the azimuth of Cheviot as 38° 48′ 58″·68. This determines the meridian; and the triangulation gives the relative distances and azimuths at the following succession of stations (selected for this calculation):—Cheviot; Mount Battock, on the Grampians between Aberdeen and Balmoral; Scarabin in Caithness, Fitty Hill in the Orkneys; Foula, a precipitous island between Orkney and Shetland; and Yell, a station in Shetland (not quite so far north as Saxaford (see Fig. 3).

On the meridian line defined above, take a point, A, whose distance from Easington is equal to the side "Easington to Cheviot." Join A with Cheviot and Mount Battock, and it is evident that we can determine the distance A to Mount Battock and the angle at A between Mount Battock and the north meridian. Next take the point D at a distance from A equal to the side "A to Mount Battock." Join D with Mount Battock and Scarabin, then we can determine the side "D to Scarabin" and its inclination to the meridian at D. Next take a point G (still in the same meridian) at a distance from D equal to the side "D to Scarabin," and join G with Scarabin, Fitty Hill, and Foula. Next take H at a distance from G equal to the side "G to Foula," and join H with Foula, Yell, and Saxaford. From Saxaford drop a perpendicular on the meridian meeting it in S; then we have the distance Easington to S, and the length of this perpendicular, which is about 200 feet. In order to verify this result a different set of stations were chosen for a second calculation conducted in a similar manner; the distance Easington to S by the first calculation was 2288427·29 feet; by the second it was 2288427·38 feet.

FIG. 3.

The volume of the Ordnance Survey entitled "Account of the Principal Triangulation of Great Britain and Ireland," by Capt. A. R. Clarke, R.E., contains (pp. 733–778) an elaborate calculation of the figure of the earth based upon the English and French arcs of eleven and twelve degrees respectively, the Russian and Indian of twenty-five degrees and twenty-one respectively, the first Indian arc, the Danish and the Prussian arcs of about a degree and a half each, the Peruvian arc of three degrees, and the Hanoverian arc of two degrees—a total length of eighty degrees within a few minutes. The figure is first investigated without restricting it to the elliptic form, but assuming that the radius of curvature of the meridian is expressed by the formula $\rho = A + 2B\cos 2\phi + 2C\cos 4\phi$ (the ellipse is a particular case of this curve, *i.e.*, if $5B^2 - 6AC = 0$). The resulting semi-axes are $a = 20927197$ ft., $b = 20855493$ ft., $a : b = 291{\cdot}9 : 290{\cdot}9$, and the meridian curve is more protuberant than an ellipse of the same axes by the quantity $\delta r = (177{\cdot}5 \pm 70{\cdot}9) \sin^2 2\phi$. But when the curve is restricted to the form of an ellipse the semi-axes are found to be 20926348 and 20855233 with the ratio of 294·26 : 293·26. The probable errors of the semi-axes so determined are ± 186 and ± 239 respectively.

Subsequently to the publication of the volume containing these investigations, an extensive series of comparisons of standards—the geodetic standards—of length of the various countries in which meridian arcs have been measured, was made at the Ordnance Survey Office, Southampton. In order that these most important comparisons might be made with the utmost attainable accuracy, a building was erected especially for this purpose. The comparison-room—itself double-walled—is surrounded and wholly inclosed within an outer building, and it is partly sunk below the level of the ground. The diurnal change of temperature is not perceptible in this room, consequently comparisons are made under extremely favourable circumstances. As a rule, each pair of standards was compared in summer at about the temperatures of 62°, and in winter at about 32° or 42°, but always at the natural temperature of the room, artificial temperatures being wholly excluded. To give an idea of the precision attained in these comparisons, the probable error of the length of the Ordnance Standard ten-feet bar in terms of the national yard is four ten-millionths of a yard; that of the Indian steel standard (a ten-feet bar) is less than three ten-millionths of a yard; that of the Russian standard, a bar of more than twelve feet long (two toises) is six ten-millionths. The importance of these results, connecting the largest arcs, upon which the figure of the earth must depend, can hardly be over-estimated. The length of the "Toise of Peru" obtained through three entirely independent sources, viz., the Russian, the Prussian, and the Belgian toises, is 6·39453348 feet, from which the greatest divergence of the three separate results is only half a millionth of a toise; this corresponds to ten feet in the earth's radius. The length of the "metre" deduced from the above by means of its defining ratio (443296 : 864000) is 3·28086933 feet.

One of the most difficult of the determinations of length made in connection with this series was the measuring the distance between the knife edges of Kater's Reversible Pendulum. In this operation the flexibility of the bar was in the preliminary comparisons a source of much error. This, however, with some other troublesome matters, was successfully overcome, and the length was determined with a probable error of less than one five-millionth part of the length. The length of the pendulum was obtained by comparing it with the metre, and the details of the measurements will be published in the "Account of Pendulum Observations in India," by Col. Walker, R.E., F.R.S., Superintendent of the Great Trigonometrical Survey and Surveyor-General of India.

These results of the comparisons of standards of the different countries concerned, modify the numbers given above for the semi-axes of the earth. After making the necessary corrections, the semi-axes of the elliptic meridian are 20926062 feet and 20855121 feet, or 6378206·4 metres and 6356583·8 metres. The ratio of the axes 293·98 : 294·98. See the Ordnance Survey volume, entitled "Comparisons of Standards of Length," page 287. In the same volume will be found an investigation of the figure of the earth, supposing it to be an ellipsoid of three unequal axes.

But these results are now again superseded by a more recent determination published in the *Philosophical Magazine* for August. It appears that during the last few years the Surveyor-General of India, Col. Walker, C.B., F.R.S., Royal Engineers, has been not only measuring new arcs in India, both of latitude and of longitude, but has revised the southern portion of the Indian arc as measured originally by Col. Lambton. On this chain of triangles considerable doubt rested as to what was the unit of length used in the measure; a complete remeasurement according to modern methods has set this question at rest. A complete meridian chain of triangles has been carried from Mangalore on the west coast in latitude 12° 52′ and longitude 75° E., to a point in latitude 32°; thus the whole Indian arc is now 24° in length. Eleven differences of longitude have been determined by electro-telegraphy between the stations Mangalore, Bombay, Vizagapatam, Madras, Bangalore, Hydrabad, and Bellary; it is almost unnecessary to add that in these operations no refinements of modern science have been overlooked. As the difference of longitudes of Bombay and Vizagapatam is 10° 28′ and the geodetic connections of the above seven stations is completed (liable, however, to some small future corrections resulting from the least square calculations) there is thus presented a large addition to the data of the problem of the figure of the earth. Taking the English and French conjoined arc of 22° with fifteen astronomical stations; the Russian arc of 25° with its thirteen stations; the Indian meridian arc of 24° with fourteen stations (this is not a fourth part of the number available), and the Indian longitude stations specified above, fifty-six equations treated by least squares give the following elements of the earth's figure :—

Polar semi-axis ... ... $c = 20854895$ standard feet.
Equatorial semi-axis ... $a = 20926202$ " "
$c : a = 292{\cdot}465 : 293{\cdot}465.$

But the evidence of the Indian longitude observations goes to show that the curvature of the surface of India in a direction perpendicular to the meridian is considerably less than that belonging to the spheroid just specified. Possibly this apparent result may be owing to the existence of attractions of the plumb-line seawards at the coast stations. At any rate it suggests the re-investigation of the ellipsoidal form of the earth: and the result of a formidable calculation is that the ellipsoid best representing all the observations has the following semi-axes :—

$a = 20926629 \quad b = 20925105 \quad c = 20854477,$

and the ellipticities of the two principal meridians

$$\frac{1}{289{\cdot}5} \text{ and } \frac{1}{295{\cdot}8}.$$

The longitude of the greater axis of the equator is 8° 15′ W. of Greenwich—a meridian passing through Ireland and Portugal, and cutting off a portion of the north-west corner of Africa; in the opposite hemisphere this meridian cuts off the north-eastern corner of Asia and passes through the southern island of New Zealand. The meridian containing the smaller diameter of the equator passes through Ceylon on the one side of the earth and bisects North America on the other. Thus the division of the earth by the meridian plane of the greater axis of the equator corresponds very nearly with the ordinary two-circle representation of the earth, the one showing the Eastern hemisphere the other the Western.

Such is the result of the calculation, and it is a somewhat remarkable result when considered in connection with the actual physical features of the globe, and the distribution of land and sea on its surface. But too much confidence must not be placed in it; many more measurements would be necessary to establish this figure as a reality; as yet it is merely indicated by the existing observations, and the amount of the eccentricity of the equator shown above is really very minute.

It is to be observed—returning to the spheroidal figure and comparing this new result with that quoted above from the volume of "Comparisons of Standards"—that the effect of the new work in India has been to increase the radius of the equator by 140 feet, and to diminish the polar radius by 226 feet.

There are several short arcs on the European continent which might have been used in addition to the long arcs, but the influence of these on the result would have been almost imperceptible. The details of the American Coast Survey oblique arc are not yet published.

Notwithstanding the immense additions to geodetical measurements and to the data of the problem of the figure of the earth since Bessel's investigations (1841), it is with a good deal of truth that Karl Maria Friederici says that Bessel's results are still universally adopted by scientific men. And this must be considered a very remarkable instance of the influence of a *name.* Bessel was a splendid mathematician; his works are characterised by great elegance; and in this case his fame is a set-off against the increase of data subsequent to his time. But Bessel could only use one-fourth part of the present English arc (and the terrestrial measure of this arc as used by him was some 200 feet in error), and one-third of the present Russian arc. In his time the English, Russian, and Indian arcs amounted in all to less than 27°; now they exceed 57°. Hence Bessel's figure of the earth cannot be considered anything else than obsolete, however excellent it may have been six-and-thirty years ago.

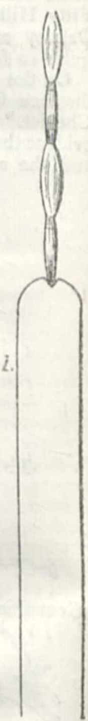
The operations which are being conducted with so much activity on the European continent and in India must shortly put us in possession of great additions to the data of the problem, especially through the agency of the electric telegraph. As a specimen of the precision now attainable in the determination of longitudes by galvanic signals, we may quote the three results obtained at different times and in different ways for the difference of longitude of Greenwich Observatory and Harvard Observatory (Cambridge, Massachusetts). They are as follows :—

	h.	m.	s.
In 1866, by Anglo-American cables	4	44	31·00
In 1870, by French cables to Duxbury	4	44	30·99
In 1872, by French cable to St. Pierre	4	44	30·96

Doubtless there is a certain amount of good fortune in this, but nevertheless the accordance is highly satisfactory.

AN EXPERIMENTAL INVESTIGATION OF THE STRUCTURE OF FLUID COLUMNS WHICH ARE AFFECTED BY SOUND

WHEN a fluid escapes from a contracted opening, it may form a column, which throughout the greater part of its length has the same sectional shape as the opening. This kind of column may be called prismatic.



It may after leaving the opening form an expansion, this expansion being succeeded by another at an angle (usually a right angle) to it; and this latter by another, and so on. This kind of column may be called segmental (Fig. 1).

An example of the first is obtained when the column proceeds from a true cylinder, truncated at right angles to its axis, and is very difficult to obtain.

A segmental column is easily obtained from the end of a partially closed glass tube.

Segmental columns are sensitive, prismatic columns not sensitive, to sound.

The character of a jet is determined by connecting with a water supply.

The apparatus, Fig. 2, is intended to show the structure of a segmental column. *a, b, c, d* is a piece of cork $2\frac{1}{2}$ in. × 1 in. and 1 inch thick. Pieces of glass tube 2 inches long serve as axes for the corks C C. Each cork is pierced at right angles to its axis to support a jet J. An india-rubber T-piece connects the jets with gas or water supply.

It will be seen that the arrangement permits of the jets being inclined to each other at any angle by the movement of the corks round their axes; and a lateral adjustment may be obtained by sliding them along their axes.

To make the jets: the middle of a long piece of glass tube is contracted in the blowpipe flame; when cold a sharp scratch is made in the middle of the contraction, and the tube broken through. Two perfectly equal jets are thus obtained.

Experiment I.—Arrange the jets at an acute angle and connect with a water supply. The segmental column will be obtained. The first (primary) expansion being at right angles to the plane of the jets.

Experiment II.—Keeping the water supply as before, increase the angle of the jets; the segments will become more marked and the length of the entire column decreased. At a certain angle the primary expansion becomes so great that the cohesion of the

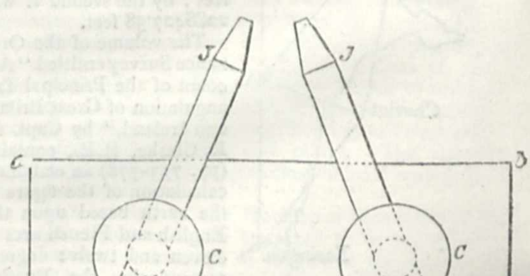


Fig. 2.

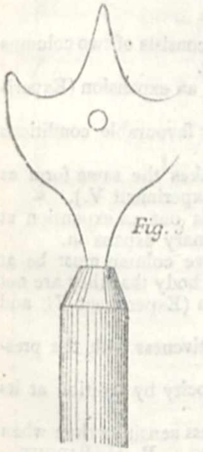
different parts will be overcome, and the column be fan-shaped.

The ordinary fish-tail burner furnishes a familiar example of this extreme segmentation.

Note.—As every degree of segmentation may be obtained with suitable inclination of the jets, it follows that a segmental column really consists of two similar ones, meeting at an angle.

Experiment III.—Arrange, as in Experiment I., but connect with a gas supply and ignite. The primary expansion will be obtained but not succeeded by any other. This is readily accounted for. The edges of the expansion, as far as the middle, are receding from each other, and there being no cohesion in gases, they continue to recede, and so the expansion is fan-shaped.

Experiment IV.—Starting with the jets at an angle of about 60° and their ends nearly in contact, lessen the angle and adjust the gas supply, that the flame may take the shape shown in Fig. 3. At a certain point increase of gas will cause the flame to emit a note (usually a very high one), and at the same time commencing somewhere about o[1] there will be an expansion at right-angles to the primary one. A horizontal section of the flame will now have a cruciform contour.



Having obtained this musical flame, withdraw the jets through their corks (keeping the same angle throughout). As the distance between them increases the note becomes of lower pitch. With careful attention a very low note may be obtained. At a certain distance the note ceases, but may be restored by additional gas pressure.

Note.—It is evident that the velocity of the gas decreases with its distance from the jet. Hence the greater the velocity the higher the note.

I have shown (NATURE, vol. xv. p. 119) that the velocity of the escaping gas is decreased by ignition, therefore if a certain flame produces a low note the same column unignited will give a higher one. This is found to be the case.

Experiment V.—Having arranged, as in the preceding experiment, reduce the gas supply till the flame ceases to sing. It will now be sensitive to a certain note. Produce this note very near the flame, the flame takes the same shape as when singing (Experiment IV.).

Experiment VI.—Produce a flame tolerably sensitive (Experiment V.). Mount a whistle so that it may revolve round the flame. In two positions, being the ends of a diameter passing through the edges of the flame, the sound will produce no effect.

Note.—It will be seen that the sonorous impulses strike the flame in such a manner that the two columns are thrown into the same phase of vibration. The maximum effect is produced at points at right-angles to the minima. The waves reaching the nearer column first will throw it into a phase differing from the distant one.

Experiment VII.—Select jets of such a size that a flame may be obtained as large as one's hand. At a pressure just below that at which it sings it will be highly resonant.[2]

A sound produced in its vicinity will cause it to resound. When the exciting note has ceased, the sound of the flame will gradually subside; at the same time giving forth higher and higher harmonics of the note.

The sounds, however, are very feeble, and can only be heard at a very short distance. A convenient arrangement for amplifying the sound, is to place the stoppered end of a large gas jar in contact with the ear, and direct the open mouth towards the flame. With a correct adjustment any note within a very wide range will excite the flame, which may emit the same, or some harmonic of it. By whistling an air with the mouth, a rather pleasing accompaniment is heard, and the extreme gravity of some of the flame-notes is certainly remarkable. I have not succeeded in augmenting the notes so as to make this a lecture experiment.

Fig. 4 consists of a cork or other suitable material about 6 in. long, and 1 in. wide and thick. The axis of a jet A is directed to just pass clear of the top of a jet B. A is supported in a cork so that it may approach or recede from B. The end of A is contracted till it will give a flame about 1½ inch long, under the full pressure of the gas mains ($\frac{1}{10}$ in. water).

When tested with water it should show very slight segmentation.

Experiment VIII.—Produce at B the smallest possible flame, and direct the full flame from A, so that the point just passes over the top of B. Extinguish A without turning off the gas. The issuing gas will form a bluish cone beyond B, the space between A and B remaining unignited.

A may now be withdrawn from B till the cone becomes unsteady. If the column has very slight segmentation the distance may be five or six inches. With most jets, however, the limit will be about three or four inches.

This column is exceedingly sensitive. The faintest sound to which it responds will cause the ignited cone to recede towards A.

The greater length, and therefore the greater velocity of the unignited column will be at once noticed (*vide* Experiment IV.)

Experiment IX.—Arrange as Experiment VIII., and remove A just so far, that the cone does not strike back to it. Now very softly produce the responding note. The column recedes and becomes ignited through the whole of its length.

Experiment X.—Replace A by a rather more segmental jet, and obtain the cone. It will be seen that when the cone recedes, it is divided at the extremity more or less perfectly, into two parts.

Experiment XI.—Replace the jet B by a disc of spongy platinum[1] about the size of a halfpenny.

The unignited column causes an annular patch of the platinum to become red hot. When the column is excited the annulus is divided into two spots. The same column, if previously ignited, will not be affected by the same sound.

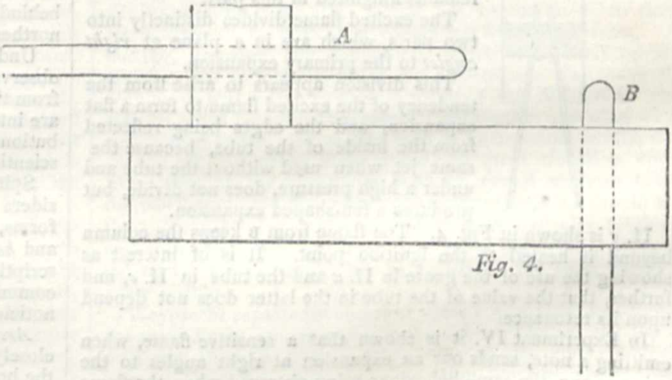
This forms another proof of the excitability of the unignited column.

In Fig. 5 two equal jets inclined to each other at an acute angle, are fixed in a cork which freely slides in a tube 5 in. × ⅝ in.

Experiment XII.—Using the apparatus (Fig. 5), slide the cork near the top of the tube and ignite the gas. Slowly lower the cork till a point is reached at which the flame is sensitive. Observe that the base of the quiescent flame in contact with the tube forms a sinuous line, consisting of two depressions and two crests at right angles to each other; and further, that the crests correspond in position with the edges of the primary expansion, and the depressions consequently with the sides.

Note.—When the flame is excited their relative positions are reversed.

Experiment XIII.—Use a low gas pressure (one or two tenths) with Fig. 5, and slide the cork down the tube till the base of the flame becomes unsteady. At a certain point a noise will cause the flame to move from side to side *in the same plane as the jets.* Increase of pressure accelerates the movement.



Instruments for the production of sensitive flames may be divided into two classes:—

1. Those in which the whole of the gaseous column is ignited.
2. Those in which the column is only partially ignited.

[1] This corresponds with the intersection of axes of the jets.

[2] A large gas supply is indispensable, and very careful adjustment is required to obtain the most favourable result. A pressure of 1½ inches of water is sufficient.

[1] A good substitute for the spongy platinum is obtained by pounding some fine asbestos till quite smooth, moistening with a tolerably strong solution of platinum tetrachloride, moulding the mass into the required shape in a piece of paper, and igniting. The paper burns off and leaves a porous fragile mass. This is alternately soaked in the platinum solution and ignited three or four times, when it becomes tolerably durable.

CLASS I. *Ignited Columns.*	CLASS II. *Partially-ignited Columns.*
a. The apparatus described by Prof. Barratt, *Phil. Mag.*, April, 1867.	*a.* Described in NATURE, vol. v. p. 30.
b. Described in this paper, Fig. 2, *et seq.*[1]	*b.* Described in a former communication, December 7, 1876.
	c. Described in this paper, Fig. 4, *et seq.*

I. *a* consists of a glass tube with a tapering jet. A V-shaped cut made across the end of the jet renders it more sensitive. If such a jet be connected to a water-supply it will be found to be segmental. If it has the V-shaped groove this will be more marked. The primary expansion lies in the groove in most cases. The only use of the latter is to render the column more certainly segmental.

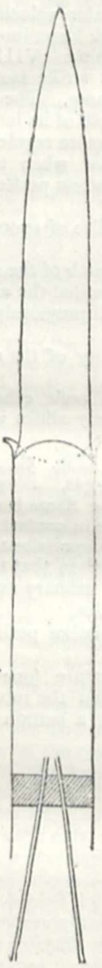


Fig. 5.

The column being segmental, consists (Experiment II., note) of two streams, one on each side the groove meeting at a very acute angle.

When there is no groove little irregularities in the orifice determine the segmentation of the column. The friction of the long, narrow jet and the ignition of the gas at the orifice retard the outflow, and to obtain a sufficient velocity the gas must issue under a considerable pressure[2] (one or two feet).

When excited it shortens and expands at *right angles to its primary expansion.*

I. *b* has been described (Fig. 2, *et seq.*). The jets meeting at a considerable angle, the column is flattened. It responds in the same manner as the preceding, but the primary expansion being very short, the responding expansion is usually the longer one.

II. *a* consists of a tapering jet placed a small distance below a piece of fine wire gauze. The gas is ignited above the gauze. It is very sensitive, but the intersection of the column by the gauze prevents the flame from taking any well-marked form when responding.

II. *b* is practically the same as the foregoing. The column being surrounded for a part of its length by the closed tube, remains unignited in this part.

The excited flame divides distinctly into two parts, which are in a plane at *right angles* to the primary expansion.

This division appears to arise from the tendency of the excited flame to form a flat expansion, and the edges being reflected from the inside of the tube, because the same jet when used without the tube and under a high pressure, does not divide, but produces a fan-shaped expansion.

II. *c* is shown in Fig. 4. The flame from B keeps the column beyond it heated to the ignition point. It is of interest as showing the use of the gauze in II. *a* and the tube in II. *c*, and further, that the value of the tube in the latter does not depend upon its resonance.

In Experiment IV. it is shown that a sensitive-flame, when emitting a note, sends out an expansion at right angles to the primary one, the same behaviour being observed when the flame is excited by an external sound. It therefore follows that if these actions are conversely related to each other, that a responding flame should emit a note. This will always be found to be the case; but the sound being usually very feeble, may escape observation unless some means be adopted to concentrate it (*vide* Experiment VII.).

The expansion occurs just above the intersection of the axes of the jets. Call these *a* and *b*. The two columns strive for a mastery of direction. *a* overcomes *b* and sends a tongue of flame through the primary expansion, but the partial stoppage of *b* causes an increase of pressure by which in turn it overcomes *a*, and sends a tongue of flame through the other side of the primary expansion, and so on. These movements succeeding each other with very great rapidity in a high note, and gas being highly elastic it is impossible to recognise them separately. Experiment XIII. shows how the impulses may be obtained so slowly as to be individually perceived.

When the gas pressure is so low that the column is quiescent, a sound is necessary to start the operation; and further the sound must so strike the component columns as to give one of them an advantage (*vide* Experiment VI.).

I have only referred to water columns as far as was necessary to illustrate the behaviour of gaseous ones. They should form a subject for separate consideration.

Summary.

1. A fluid column if sensitive to sound consists of two columns meeting at an angle (Experiment II. *note*).
2. The resultant of the two columns is an expansion (Experiments II. and III.).
3. A column so constituted will under favourable conditions emit a note (Experiment IV.).
4. If excited by an external sound, it takes the same form as when it spontaneously emits the sound (Experiment V.).
5. A column excited as in 3 and 4 sends out an expansion at an angle (usually a right angle) to the primary expansion.
6. The component column of a sensitive column must be at such unequal distances from the sounding body that they are not thrown into the same phase of vibration (Experiment VI. and *note*).
7. A gaseous column increases in sensitiveness with the pressure, *i.e.*, the velocity.
8. A gaseous column is lessened in velocity by ignition at its origin (Experiment VIII.). Hence—
9. A gaseous column when ignited is less sensitive than when unignited (Experiment IV.).

R. H. RIDOUT

[1] Lecomte has previously shown that the fish-tail burner is sensitive.

[2] By making a V-groove across the end of a partially-closed tube, this kind of jet becomes tolerably sensitive at a pressure of three inches

THE AURORA OBSERVATIONS OF THE AUSTRO-HUNGARIAN ARCTIC EXPEDITION, 1872-74, *BY CARL WEYPRECHT*

THE Austro-Hungarian Arctic Expedition of 1872–74 was in many respects an unfortunate one. Not only was the first winter occupied with an unintermitted struggle with the ice, which from hour to hour threatened to crush the ship, and rendered it imperative that everything should be in constant readiness for her sudden abandonment, but in the second year this had actually to take place, and, on account of their bulk, valuable records of scientific observation were unavoidably left behind, and among these was the carefully-kept journal of northern-light observations.

Under such discouraging conditions the mass of valuable observations which Lieut. Weyprecht has succeeded in collecting from the meteorological and magnetic journals and other sources, are interesting not only on account of their many positive contributions to our knowledge, but as an example of wonderful scientific industry and devotion.

Spite of the perpetual changes of the aurora, Weyprecht considers that its appearances may be classified under five distinct forms, viz., the *arch*, the *ribbon* or *streamer*, the *rays*, *crown*, and *haze* (*Bogen*, *Band*, *Fäden*, *Krone*, and *Dunst*). His description of these forms differs in several particulars from those common in lower latitudes, so that we may be excused for noticing them at some small length.

Arches (*Bögen*, *arcs*) are of regular form; the highest point closely coincides with the magnetic meridian and the ends cut the horizon at points equi-distant from it. They usually move either northward or southward, rising from the edge of a low dark segment near the horizon, or again vanishing into it. The rim of light which edges this dark segment is probably only a low and distant bow, or possibly the combined effect of all the remoter arches which are melted into each other by distance and perspective. This is the more likely since a bow is never observed to sink wholly below the horizon, but fades into this distant rim, and, conversely, from it, arches frequently arise and separate themselves as they get higher. Not unfrequently the arches sink back to the point from whence they arose; at other times they gradually fade away as they near the zenith, or after they have passed it. Very intense displays never take the form of regular arches.

While in low latitudes the arch is one of the most frequent of auroral forms, in the polar regions this post is occupied by the *ribbon* or *streamer* (*Band*), which resembles a torn and irregular arch, and may take any position or direction, one or both the ends being usually visible above the horizon. It takes the most varied and ever-changing forms, forcibly suggesting a pennon floating on the breeze, doubling and curling on itself in graceful and translucent folds, or again appearing as if torn into shreds blown by the wind. Weyprecht is inclined to believe that the wind actually has some influence on the northern lights, and notes that, after severe and widely-extended storms, the streamers are especially ragged and broken. While in the arch the light intensity changes but slowly, and simultaneously over the whole bow, the reverse is the rule with streamers, in which it varies irregularly, lightening in one place and fading in another. The rapidity of these changes is very varied. Sometimes a band will drift slowly across the northern or southern sky, without change of form or colour, for a long time together, and then suddenly flame up with rapid movement across the zenith to form a crown, to renew its play, or to vanish on the other side. Frequently pieces break off and form new bands, which spread over the whole heavens, and then again fade down to a single band of a new form, or perhaps carry on their game until the dawn drives them from the sky. In most cases the light of the streamers has a peculiar motion, resembling waves which roll continuously from one end of the band to the other. These waves are more intense and move more rapidly in proportion to the activity of the bands themselves. The streamers vary in their appearance, sometimes seeming to consist of a uniform light-material like most of the arches, at others of closely-packed perpendicular rays, with the intervals filled with the same light-material. Between these two extremes are all intermediate gradations. When the rays are visible each brightens as the wave passes over it, but does not change its position except by a slight lengthening, which gives the hopping or dancing motion which, no doubt, is the origin of the term "merry dancers." When, on the other hand, the streamers consist of simple "light-material," the waves cause a brightening and slight undulatory motion of the edge.

Admirable illustrations of these streamers, as they are occasionally seen in lower latitudes, may be found in Prof. Piazzi Smyth's Edinburgh astronomical observations, under the name of "multiple arcs," but they are already approximating to regular arches, from which they probably differ only in distance and altitude. This work also contains most valuable plates and observations of the auroral spectrum, as compared with that of twilight and the zodiacal light. The *threads* (*Fäden*, *rayons*) are fine rays of light directed from the magnetic zenith to the horizon, but not quite reaching either. They occur sometimes singly or in bundles, sometimes pretty uniformly distributed, and are very variable in length. Their breadth rarely exceeds one minute of arc, and they are separated from each other by dark spaces. Their motion is peculiar, and seldom rapid. They lengthen and shorten upwards or downwards, giving the impression that already existing threads are lighted up or fade. They also move slowly from west to east or east to west, and not unfrequently it seems rather that the light is transferred gradually from one thread to another than that the threads themselves actually move.

The threads are evidently in intimate connection with the streamers. Often they stretch from near the magnetic zenith like a fan or a veil of gold or silver threads, of which the streamer forms the broad lower border; singularly, however, they rarely actually reach it, but seem to fade away near its edge, only to reappear with greater brightness in the streamer itself. This phenomenon is seen in the most beautiful way where two bands appear at once, one over the other, and each with its proper fringe of threads, like a silvery veil, falling in the most graceful folds. It is, however, only occasionally that threads and streamer occur in combination, and in the feebler displays it is more usual to see fans of threads, or streamers alone than both at once.

The *crown*, as is well known, is the perspective effect produced round the magnetic zenith, towards which the auroral beams, following the lines of magnetic force, seem to converge. The intensity of the appearance is very variable, and at times becomes such that thousands of short broad flashes dart at once from or towards the centre, while the whole firmament is covered with widespread rays, which lengthen and shorten with a flickering motion. Broad bright flames leap about the centre as if driven by a fiery whirlwind, and all the heavens seem in flames. In general the more brilliant the appearance, the shorter is its duration, and though it sometimes happens that masses of light move for hours about the centre, yet in such cases the brilliancy and the motion are alike feeble.

As a rule a crown is formed whenever an aurora of pronounced form passes the magnetic zenith, *i.e.*, when the beams of which it is composed are parallel with the observer's line of sight. Faint auroræ, however, especially arches with slow motion and no rays, may pass the zenith without forming a crown, and, on the other hand, a feeble crown sometimes becomes visible without the passage of any noticeable band or arch. When, as sometimes happens, the streamer is formed of uniform "light-material" without distinct rays, rays are also absent from the crown, which consists merely of lambent flames flickering round the centre, and resembling those of alcohol burning on a flat surface.

The *haze* (*Dunst*), as its name implies, resembles a faint mist, from which, by moonlight, it is scarcely distinguishable, as its light is never intense.

With regard to *colour*, Weyprecht observed that in bands the red always formed the lower and green the upper part, the middle being whitish. The haze was frequently reddish, but dull greenish seems to have been the prevailing colour, which is compared to that of the electric spark. Most unfortunately the expedition was unprovided with any spectroscope suitable for such observations, so that on this most important point we have no information to record.

The intensity of the light was such that the smallest type was frequently legible, and larger could be read easily. Weyprecht proposes to measure the intensity of the aurora by observation of the legibility of print of different sizes.

With regard to the height of the northern lights above the earth's surface, Weyprecht is strongly of the opinion that they are much lower in the arctic regions than in lower latitudes, but was not able to make any direct measurements. Their brilliancy and distinctness, and, above all, their rapid movements, give the impression of nearness; and the observations of Parry, Farquharson, and others, lead to the same conclusion. On one or two occasions the aurora appeared to be below the light cirrus clouds, which do not attain a maximum height of more than 8,000 metres; but the observation was by no means certain. Auroræ were also repeatedly visible when the sun was so little below the horizon that the height of the direct sun-rays in the zenith was not more than from six to twelve miles. If, as has been suspected, the auroral light depends on some form of mist for its basis, this would have been rendered visible had the height been such as to bring it into the sunlight; but if, as is generally supposed, it depends on the electrification of rare and transparent gases, this would not be the case; so that it seems difficult to draw any conclusion from these facts. Admitting, however, the conclusion, which is in itself probable enough, that in high latitudes the appearances are lower than with us, it will go far to explain many of the differences which may be noted between Weyprecht's description and what we are accustomed to see. Streamers such as he describes would, if far enough off, and owing their altitude to great elevation, appear like arches, as the lower edge is at an almost uniform height, the windings would disappear with distance, and we should have the appearance of a pretty regular arch of irregular brightness and with beams shooting from it towards the zenith, while the individual threads would be, as is indeed the case, rarely or never visible.

Weyprecht repeatedly observed clouds and mist which took the same forms as aurora, and strongly resembled it; but he does not think a case is made out for any real connection between the two phenomena. The stars, however, are decidedly obscured by an intense aurora, and many observations seem to point to some such connection. Several very interesting ones are quoted by the present writer in the article "Aurora" in the last edition of the *Encyc. Brit.* Weyprecht frequently uses the phrase "light-material" in speaking of the aurora, and it is evident that there must be some material basis to the phenomenon. This, he suggests, may be the minute ice crystals, which are the cause of mock suns and moons, appearances of daily occurrence in the polar regions. It seems certainly possible that these may be projected far above the earth, or even above the atmosphere by electrical repulsion, and may serve as carriers of electrical discharges, which would at once illuminate the particles and arrange them in the lines of magnetic force. If the aurora is really, as is commonly supposed, an electric discharge in a rarefied gas, it must admit of a very considerable range of density, since it is certain that even in the same aurora, different portions are at very different elevations. In the crown for instance, the beams are almost perpendicular, and must be often of very great length.

The aurora has frequently been supposed to be a sign of coming wind and stormy weather, but careful comparison of the meteorological records failed to establish any such connection. No sound could be attributed to the northern lights.

Weyprecht's observations confirmed the fact that there is a zone of maximum frequency and intensity of auroræ some distance south of the pole, and led further to the conclusion that the zone moves northward towards the winter solstice, and southward again towards the equinoxes. It is of course impossible to observe its course during the summer.

Observations of the daily period gave a maximum at 10 P.M., and a minimum at 11 A.M., which closely coincides with the results of other observers.

No very clear conclusion could be drawn as to a yearly period, since the length of the nights, the cloudiness of the sky, and above all, the before-mentioned shifting of the zone of maximum frequency so complicated the problem.

Want of space unfortunately forbids us to enter into any detailed discussion of Weyprecht's extensive magnetic observations. Many magnetic disturbances were unaccompanied by aurora, and on the other hand, some aurora produced little or no magnetic variation. Those appearances which have an indistinct outline and diffused light, and especially which have no rays and and no noticeable motion, scarcely affect the needle; while, on the contrary, those which appear to be low and near, which have distinct contour and rapid motion, and above all sharply defined rays, affect the needle vigorously. Broad darting lightning-like rays, with brilliant colours, red and green, cause the most violent disturbances. HENRY R. PROCTER

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

WE are pleased to find that local schools of science are increasing their facilities for teaching practical chemistry to their students. During the summer the committee of the Birkbeck Institution (the first London Mechanics' Institute) has built a new chemical laboratory, to replace the somewhat inconvenient one which has done service for fifty years. The space available was very limited, but has been made the most of, and nineteen benches have been fitted up in a space of 36 feet by 10½ feet, besides the necessary accommodation for stores, &c. This effort to meet the requirements of students is all the more commendable, on account of the probability of the Institution remaining but a few years longer in its present home. Its success is so great that a new and larger building is absolutely necessary, and the building fund being raised amounts already to nearly a thousand pounds.

SOCIETIES AND ACADEMIES

PARIS

Academy of Sciences, September 16.—M. Fizeau in the chair.—The following papers were read:—On the cause of the periodic movements of flowers and leaves, and on heliotropism, by M. P. Bret.—On a new telephonic transmitter, by M. P. Dupont.—Remarks on a new proposal made with regard to the analysis of milk, by M. E. Marchand.—Description of a new apparatus for the transfer of gases from one vessel to another, by M. A. Blanc. The appatatus is constructed with the special view of avoiding any loss of gas on its being transferred over mercury.—Various communications regarding phylloxera, by MM. E. Fortier and Capbladoux.—On the intra-Mercurial planet seen in the United States during the solar eclipse of July 29 last, by Mr. Swift.—On the observations made of the transit of Mercury on May 6, 1878, at the Imperial Observatory of Rio de Janeiro, after the new method, by M. Emm. Liais.—On the form of the integrals of differential equations of the second degree in the neighbourhood of certain critical points.—On the compressibility of gases at high pressures, by M. E. H. Amagat.—New researches on the physiology of the vesicular epithelium, by MM. P. Cazenove and Ch. Lyon.—Note on the interior temperature of the globe, by Mr. W. Morris.—Note relating to an apparatus named galioscope, by M. A. Boillot. This apparatus is constructed to demonstrate the invariability of the direction of the plane of oscillation of a pendulum.—Note relating to a new thermohydrometer, by Mr. H. Douglas.

September 23.—M. Fizeau in the chair.—The following among other papers were read:—Dissociation of oxides of the family of platina, by MM. Saint Claire Deville and Debray. Osmium and ruthenium combine directly with oxygen, and the product of oxidation is volatile and forms at the highest temperatures. In this they are distinct from the other platinic metals, and come near arsenic and antimony, with which they might be placed among the metalloids. From experiments with oxide of iridium the authors show that, at a temperature below 1003·3°, it is decomposed in free air, and consequently that, at this temperature or any other higher, iridium is absolutely inoxidable in the air.—Memoir on a universal law relative to the dilatation of bodies, by M. Levy. This is designed to prove that the pressure which any body supports can only be a linear function of its temperature, so long as this body does not change its state; in other words, and under a physical form, if any body be heated with constant volume, the pressure which it exerts on the immovable walls of the inclosure containing it, can only increase, rigorously, in proportion to its temperature. This, he thinks, an absolutely rigorous corollary from the two fundamental propositions of the mechanical theory of heat, and of the hypothesis that the mutual actions of the atoms of bodies are directed in lines which join their points of application, and only depend on the distances of these points apart.—Nocturnal variations of the temperature at different altitudes recorded at the observatory of Puy-de-Dôme, by M. Alluard. He has traced, for each month since January, the curves of minimum, maximum, and mean temperatures of the two stations, and it appears that the two curves of minimum temperature often cut each other, both in summer and in winter, so that, often, at night, it is less cold at the top of the Puy-de-Dôme than at Clermont, the difference sometimes reaching five degrees. The curves of maximum temperature do not intersect; they are in general nearly parallel. The temperature at night, then, varies with the height, quite otherwise than during the day. A new meteorological station has been formed about midway between Clermont and the summit of Puy-de-Dôme, the three heights being thus—400 m., 1,000 m., and 1,470 m. It is purposed, too, to take observations on some of the numerous extinct volcanoes (in form of truncated cones) about the Puy-de-Dôme, the object being to study the atmosphere, layer by layer.—Discovery of a small planet at the observatory of Hamilton College, Clinton, by Mr. Peters.—On a new species of curves and of anallagmatic surfaces, by M. Picquet.—On the development of chilostoman bryozoa, by M. Barrois. This he finds *mesoblastic*, the exoderm gives rise to all the organs and plays the part of a veritable blastoderm.—M. Lancy presented a work by M. Ennes, surgeon in the Portuguese army, on "Men and Books of Military Medicine."

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