THURSDAY, SEPTEMBER 4, 1879

THE HUMAN SPECIES

The Human Species. By A. de Quatrefages, Professor of Anthropology in the Museum of Natural History, Paris. (London: C. Kegan Paul and Co., 1879.)

THERE is possibly no science which is so generally misunderstood, and yet has had so many works of popular exposition, as anthropology. It is but a few years ago that the works of Latham, Lawrence, Pickering, and Prichard formed almost solely the consulting literature of the science in this country; and without referring to the various standard works that have since been contributed on special branches of the subject by English workers, the exclusively English reader has perhaps been enabled to consult the translated works of continental anthropologists to a greater extent than has been the opportunity of the student in other fields of science. During the last fifteen years volumes of Blumenbach, Broca, Gastaldi, Peschel, Pouchet, Topinard, Vogt, and Waitz have appeared in this country in our own language, and now to the list may be added the work of the distinguished naturalist under notice, whose name, however, will be popularly remembered as the author of "Rambles of a Naturalist on the Coasts of France, Spain, and Sicily," which appeared in London in 1857.

Naturally, among the above treatises, there are to be found wide divergences of views, and perhaps the student of anthropology should be above all others careful to avoid the scientific extremes of either a Paul or Barnabas persuasion. It is, however, absolutely necessary that we should understand our author, especially that we should learn whether he approaches the consideration of the study of man with any preconceived notions, which may be peculiar to himself or not generally held by other thinkers. This M. de Quatrefages promptly discloses in the first division of his book, entitled "Unity of the Human Species," a subject which seems still somewhat of a burning question among French anthropologists. The question as to there being a fundamental distinction between man and other animals is settled in the affirmative, and for the following reasons:—

1. Man has the *perception of moral good and evil*, independently of all physical welfare or suffering.

2. Man *believes in superior beings* who can exercise an influence upon his destiny.

3. Man *believes in the prolongation of his existence after this life*.

Readers of Lubbock, Spencer, or Tylor will perhaps scarcely accept this as the philosophy at least of primitive man, but, in justice to M. de Quatrefages, we must endeavour to obtain his definition of the moral and religious stage, and this again is clearly set forth in the following sentence:—"The learned mathematician, who seeks by the aid of the most profound abstractions the solution of some great problem, is completely without the moral or religious sphere into which, on the contrary, the ignorant, simple-minded man enters when he struggles, suffers, or dies for justice or for his faith."

In discussing the different colours of mankind, melanism is considered to be the result of accidental variations, and is compared with that which, appearing in our poultry-yards from time to time, is only prevented from spreading by the destruction of the fowls attacked. It is a question, however, whether the occurrence of melanism in our poultry-yards is not often an instance of atavism, and it is probably incorrect to say (p. 49) that the flesh of black fowls presents a repugant appearance, and for this reason the propagation of the variety is prevented, when, as is generally well known, fowls of the black Spanish breed are greatly valued as table birds. This section concludes with a discussion of the vexed term "species," and, according to M. de Quatrefages, *knowledge of facts* preceded *terminology*, and his arguments compel him to the opinion that "species is then a reality." Without, however, going so far as to say with Goethe that species exist only in the copybooks of the specialists, is it not certainly a fact that the founders of zoological nomenclature and classification based their conclusions then, much as we do, and necessarily in zoological descriptions of to-day, on the general outward resemblance and structure of living forms, and that knowledge of facts more frequently follows terminology, as any well qualified and exhaustive monograph of an animal group that has been long worked and studied by zoologists of different views and methods will exhibit? Few ornithologists, in describing a new fruit-pigeon from abroad, are guided by the researches of Darwin on the multitudinous variations of the domestic pigeon at home; and as for the descriptive entomologist, he, at least, can hardly realise species as a reality with his present limited knowledge of the life histories of exotic insects. In a philosophic sense the word species, as a rule in zoological literature, is a useful biological conventionalism, as necessary but as difficult to rigidly define as the term atom, and often playing as valuable a part in classification or generalisation as the "imaginary quantity" of the mathematician fulfils in the course of his calculations. It is for these reasons that we have found a difficulty in following M. de Quatrefages in all the rigidity of his specific definitions.

The second portion of the work is devoted to the "origin of the human species." To the question whether it is possible to explain the appearance on our globe of a being "which forms a kingdom to itself," M. de Quatrefages does "not hesitate to reply in the negative." It is to be noted how such an eminent naturalist as our author is still opposed to Darwinism, which in this section receives copious treatment, and some of the grounds principally given for its rejection are to many minds who embrace it the reasons of their faith. "The positive knowledge which has been won by nearly two centuries of work" is not considered by Darwinists to be invalidated, but rather illuminated, by the light of "natural selection," and facts which were unmeaning before, now by its aid form one harmonious whole in an evolutionary cosmos. It is remarkable that the doctrine of "natural selection" appears to have been a greater stumbling-block to the French mind than might naturally have been expected, whilst in German thought it seems to have at once supplied a want. Is it that French biology has never cared to depart from the glory that illumines the work of the illustrious Cuvier, and, like other schemes of philosophy, remains true but riveted to the teachings of its founder? Even M. de Quatrefages recognises something of this, and speaks of "the reserve, perhaps exaggerated, which Cuvier imposed upon himself, and the confidence which was placed in him" as having weighed heavily upon science by impeding the comprehension of the value of new observations.

In discussing the antiquity of man, the present geological epoch is considered with "almost absolute certainty" as having commenced less than 100,000 years ago, and the opinion is pronounced that no facts have as yet been discovered which authorise us to place the cradle of the human race elsewhere than in Asia. As to the appearance of primitive man, our author concludes that "all that the present state of our knowledge allows us to say is that, according to all appearance, he ought to be characterised by a certain amount of prognathism, and have neither a black skin nor woolly hair. It is also fairly probable that his colour would resemble that of the yellow races, and his hair be more or less red. Finally, everything tends to the conclusion that the language of our earliest ancestors was a more or less pronounced monosyllabic one."

Once in possession of these views of our author, we can with the greater advantage read the excellent summaries and descriptions which form a large portion of the work relative to migration, acclimatisation, and "fossil races"; but perhaps the most interesting are those devoted to the "Psychological Characters of the Human Species." These tend to show in a new sense the brotherhood of man, so that if political economy could be called the "dismal science," anthropology should be considered as the most cheerful of its learned sisters. M. de Quatrefages combats some of the views of Sir John Lubbock as expressed in his "Origin of Civilisation" with great force, and has some very useful reflections on the danger of attributing all sense of honesty as absent in certain races on insuffìcent data. "Nothing is more common than to hear travellers accuse entire races of an incorrigible propensity for theft. The insular populations of the South Sea have, amongst others, been reproached with it. These people, it is indignantly affirmed, stole even the nails of the ships! But these nails were *iron*, and in these islands, which are devoid of metal, a little iron was, with good cause, regarded as a treasure. Now, I ask any of my readers, supposing a ship with *sheathing* and *bolts* of gold, and nails of diamonds and rubies were to sail into any European port, would its sheathing or its nails be safe?"

In conclusion, though many parts of this work show that to the author Darwin must have lived and written in vain, and some of the portions appear as anthropology little advanced from the time of Prichard, we cannot but still feel grateful that the general literature of this little-known, but most necessary of sciences, should have been enriched by a useful though not infallible book.

W. L. DISTANT

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.*]

Parthenogenesis in a Beetle

I DO not know whether any instances have been recorded of parthenogenesis in the coleoptera, nor does the interest of the case I am about to relate consist in the discovery of the operation of a not uncommon mode of insect reproduction in a new field, but rather in its altogether abnormal and fortuitous character in the species of beetle concerned, viz., *Gastrophysa raphani*. My own observations hitherto on this species have been uniformly to the effect that unimpregnated females lay always barren eggs, and that one intercourse with the male renders fruitful all eggs subsequently laid. I bred the female in question from the egg this year, and have kept her isolated since her exclusion as an imago. She has laid, up to the present, about twenty batches of eggs consisting of about thirty-four and fifty-one alternately in the batch. Of these, some fifteen batches have been observed; and only in one of these, No. 10, to wit, consisting of thirty-four eggs, and in one of these thirty-four only were any traces of development observed. This batch was laid between the 2nd and 4th of August. On the 5th I noticed in one an appearance which is usual about this time in fertilised eggs, which I have been accustomed to think about as the "embryonic scroll," and which, on reference to Huxley's "Anatomy of Invertebrated Animals," pp. 444-445, I am inclined to think may be what is there called "the *sternal band* (*Keimstreif* of the German embryologists)." This scroll is invariably present in gastrophysa eggs regularly developing, and enables one to predict with certainty the position of the ventral aspect, and of the head and tail of the future larva. On the 6th this same appearance was more distinctly marked. On August 10 a further well-defined stage of development had been reached. On the 11th the ocelli were plainly visible. Next day I noted the antennæ, mandibles, palpi, and legs. The segments, warts, and spiracles were also to be seen. On the 12th and some subsequent days I saw plainly somewhat feeble but unmistakable and decided movements of the legs, especially of the tarsi and ungues. At this season of the year the egg should have been hatched in about ten or twelve days. I have no longer any hope of this, and all larval movements appear to have ceased. All the other (thirty-three) eggs have undergone the usual degeneration, but this one presents a striking contrast to them, showing all the external parts perfectly formed and distinctly visible, as far as the position of the larva (which is just the reverse of the usual one, namely, with the dorsum in place of the venter next the surface of attachment) allows them to be seen. There is an unusual appearance of brownish coloration towards the caudal end, the nature of which I have not made out. The failure to hatch out, however, does not hinder this from being a decided case of embryonal development in an egg laid by a female of *Gastrophysa raphani* whose virginity is assured; and it is a solitary instance occurring among some eight or nine hundred eggs laid by the same beetle both before and after and along with it, all of which (as far as observed) were normally and uniformly barren.

J. A. OSBORNE

Milford, Letterkenny, August 18

Fonts in the Rocks of Brook Courses

I BELIEVE the present an opportune time to direct the attention of geologists to the occurrence of water-graven *fonts* in the rocks of brook courses, as the season of field-work is come, and the summer conditions of our water-courses facilitate observations of this most curious and interesting, as well as deeply important, of river physics.

So long ago as two years, examining the rocks bared on a river channel for the purpose of making a section, I found *fonts* in the rocks over which the waters run (in Slievardagh coal-field, Tipperary). I had not previously known of their occurrence. Those I first found I then looked on as something exceptional, but as my investigations extended and as I learned to recognise the conditions under which *fonts* are graven, I found them to be pretty general in streams having rapid descents. Nor do I think their occurrence is generally known and noted by geologists and physicists. I have seen in print but one allusion to them—in NATURE, vol. xix. p. 76, where they are notified as observed in a river in East Africa during the dry season as a "noteworthy peculiarity."

In what hereinafter appears, I do not at all mean to question the theory given as explanatory of the large "well-like basins" on the African river; doubtless our traveller had his good reasons for his conclusions.

The mode of occurrence of these fonts in the Slievardagh brooks is, I venture to submit, as follows:—They are graven in the rocks by falling waters; these waters being the main stream, a portion (and it may be a diminutive quantity) locally detached from the main stream, or a feeder dropping into the main stream from steep, rocky sides. This is the primary cause. But along with the presence of a graving machine in the falling waters, to explain the making of the fonts a concurrent cause is necessary, as otherwise they should be looked for anywhere and everywhere on rapid descents. The conducive condition is the coincidence of falling waters with a *weakness* of the rock, such as an intersection of the division planes or fissures. I have secured a specimen font, 10 inches deep and 12 inches width across the bell-shaped mouth, in compact siliceous rock graven by a diminutive shoot of the main stream running down the depression which generally marks the edge of a division plane till it reached an intersection; at the intersection it graved a font, and issuing from this went on to the next, and there graved another (see sketch, Fig. 1). The stream, flowing round and kept up by a bed of rock dipping approximately in the direction of the current, overflows in flood-time, or generally except in dry summer weather, down the fissure A B; at the intersections the fonts were graven, and the water on leaving the lower one runs along the edge of a superposed bed. We are now bound to seek a limiting condition, as otherwise almost every pool into which there

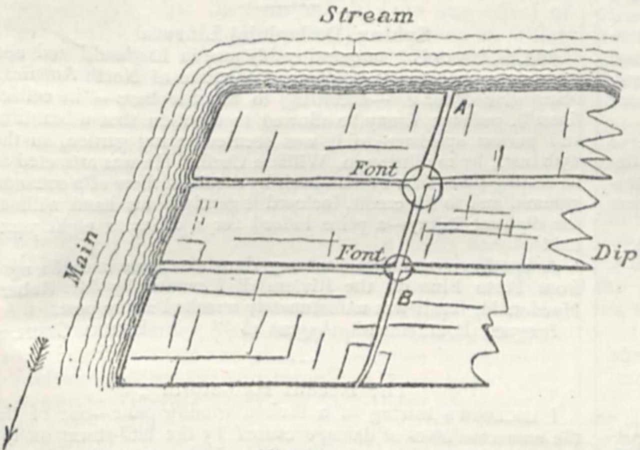

Fig. 1

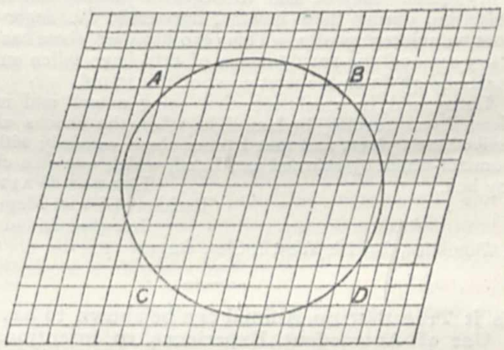

Fig. 2

is a waterfall might reasonably be expected to be a font. The limiting cause is the relation between the size of the blocks into which the rock is divided and the graving power of the falling waters. If the waterfall is sufficient to grave a font of over a certain size in rocks broken by planes into blocks of a certain size, the consequence is that the whole blocks or blocks by fragments will be broken away, and the walls will be the divisional planes of the rock and lose altogether the font shape, as is wholly or partially the case under our larger waterfalls owing to the "pigmy plan" on which our (Slievardagh) rocks are broken up by planes. Fig. 2 will explain the meaning I wish to convey. Suppose the rocks broken by two sets of planes, and there may be many sets and the stratification as well; now suppose a font graven to the size of the circle; it is plain that this could not have stability, as the blocks at A, B, C, D would have come away during the process. But had the font been so small as to take only a portion of any four blocks no discontinuance of the graving action could yet have occurred.

I may add that about 2 feet in width and depth is the size of the largest font I have come upon hitherto.

WILLIAM MORRIS

Earlshill Colliery, Thurles

The Good Time Begun

THE following has just been received from a nephew in the Bombay Presidency, who, after speaking generally of a tremendous gale from the south-west, with heavy sea, fog, &c., all along the West Coast, writes thus more particularly:—

"That same mist and rain have been for the present the saving of this Presidency from another famine. It (the rain) has been general and heavy all over the country, and was just in time to save the crops, which were fast perishing from lack of moisture. If we have a little more this month and another good fall in September, we shall be quite safe; and I do trust we shall not be disappointed, as another year—the fourth in succession—of scarcity would well nigh make 'the bankruptcy of India,' so far as Bombay is concerned, a sad fact."

You will note the appearance of this desiderated Indian rain coming from the same direction as the chief part of that which has been deluging our own country; but which Mr. Campbell shrewdly attributed, in NATURE, vol. xx. p. 403, to the sun recovering his forces and beginning already to shine, after his recent languid, spotless years, with increased radiation on the great oceans of the south.

PIAZZI SMYTH

15, Royal Terrace, Edinburgh, August 30

Insect-Swarms

IN answer to Mr. Hawkshaw's question whether any one had seen a flight of moths and butterflies in England similar to the one he observed at Trouville on August 12 and 13, I can say that on August 12 I was walking on the Dawlish Warren (a bar of sand stretching across the mouth of the Exe) and noticed a great number of *P. gamma* moths; they were close to the edge of the water; many of them were dead, and the sand hoppers were eating them, but many more were alive and trying to flutter inland, but seemed too weak to do so. I picked up some and carried them to some wild thyme and they began to feed at once. Some of the moths were in good condition but others very much battered. The wind was blowing freshly from the sea at the time. The moths swarmed in the hedges all the way from our house to the Warren, a distance of four miles, especially on the bramble flowers. There were a great many *V. cardui* with the moths in the hedges, but none on the beach. A few days afterwards I had a letter from my brother at Dieppe saying there had been a swarm of moths and butterflies there, especially mentioning *P. gamma* and *V. cardui*, but there were also skippers and clouded whites. They swarmed about the town and country and were lying dead on the beach. The swarm of moths and butterflies was also on August 12.

EDITH PYCROFT

Kenton, near Exeter, August 31

Earthquake in Dominica

A SEVERE shock of earthquake was felt here at 1.20 A.M. yesterday (Sunday) the 10th instant, and at intervals, until 1.52, there were several tremulous movements of the earth. The noise immediately preceding the first shock reminded me of the clatter which is sometimes heard on board an ocean-going steamer in very rough weather, when a heavy sea strikes the ship, and all the crockery laid out for dinner is suddenly thrown from the "fiddles" and broken into pieces on the floor of the saloon.

After the first shock there was an interval of perfect quiet until 1.30, when subterranean noises like the discharging or booming of distant guns attracted my attention, and then, at intervals varying from two to five minutes' duration, I counted six of these discharges, and following each discharge there came a gentle tremulous movement. Immediately after the last movement, heavy rain fell, and at 1.55 there were several flashes of very vivid lightning accompanied by loud peals of thunder. The rain continued to fall during all yesterday and last night.

Although Dominica is essentially of volcanic origin, and contains at the present day three active geysers, called respectively the Souffrière, the Walton Waven, and the Boiling Lake, no unusual quantity of sulphurous or mephitic vapours have lately been noticeable in the atmosphere; in fact, only one of the phenomena usually attending earthquakes preceded the shocks I have just described, and that was violent rain. The planters' "dry season" may be said to begin in January and to end in July, and during these months, harvesting, *i.e.*, sugar-making, goes on uninterruptedly. This year, however, there has been no "dry season," for 101·67 inches of rain have fallen on the east coast and 45·80 on the west coast of this island.

I may add, in conclusion, that being unwell and unable to sleep, I was reading by lamplight when the shocks above described took place, and that I timed them carefully with a chronometer-watch by Barraud and Lund, which was on a chair near my bed.

EDMUND WATT
Resident District Magistrate,
Leeward Islands

Dominica, British West Indies, August 11

Is it True that no Animal can be shown to have made Use of Antecedent Experience to intentionally improve upon the Past?

I HAD a pair of yellow African singing finches last year. The hen laid twenty-two eggs during the year, three at each nesting. In early spring I gave her materials to build with. She selected cotton wool and fine dryish grass for her purpose. It was very cold weather when she built her first nest in a little basket which I fixed high up in her cage.

The nest was a mere film of cotton wool lined with a few blades of grass. Of course the little creature could not sufficiently warm her eggs to hatch them, if they had proved fertile, which they did not.

At the end of fourteen days the cock, finding the eggs unhatched, set to work to bury them under cotton and grass (he being the only cock bird I had ever kept that built quite as well and as diligently as the hen did).

I then removed the eggs and the nest, and gave the birds fresh materials to build another nest with. They very soon accomplished this, making the nest of the same materials, *but thicker and more compact than the last.*

Again three white eggs were laid in it, but the hen could not get up the necessary degree of heat to hatch them, and at the end of fourteen days the cock set to work to build a third nest over them as before.

I again took away the nest and eggs, and I replaced the basket, this time covered externally with wadding and flannel, in hopes that thus I might help the hen to get up the proper temperature.

The little creatures immediately set to work to build again, but they this time built *a much thicker and warmer and more compact nest* than they had ever done before. The eggs proved fertile, and the process of incubation seemed to be successfully drawing to a close; but the patience of the cock did not suffice for the occasion. At the end of the tenth day he set to work to pull the cotton wool and grass about from the edges of the nest, and tried to bury the eggs as before, urging the hen to begin again also. This showed an unaccountable lack of instinct, not to say of reason; but surely the fact that the birds built each succeeding nest more and more thickly and warmly till incubation was possible indicates that they had made use of antecedent experience, and intentionally improved upon the past. These birds built a warm nest this spring, and succeeded in hatching a young one.

J. E. S.

Deltaic Growths

IN NATURE, vol. xix. p. 506, a Rangoon correspondent states that the Gulf of Martaban has shallowed 100 feet since the surveys of Captains Ross and Crawford, made probably thirty years ago. He is mistaken as to the date of these surveys for this reason:—

In 1822, at the outbreak of the first Burmese war, my father was appointed Flag Captain to Commodore Sir John Hayes's squadron, and he subsequently received the thanks of the Indian Government for, among other services, his surveys and explorations of the enemy's coasts and rivers. Now the soundings in the gulf would be about the first made. Hence the date would be 1822, or fifty-seven years ago. This shows an average annual deposit of 1·8 foot, which, although very much less than what Mr. Doyle imagines, is yet almost incredible. May there not have been a gradual rising of the sea bottom to assist?

FRASER S. CRAWFORD

Adelaide, South Australia, July 16

Sphinx (Deilephila) Lineata

As this insect is "unquestionably rare in England," and not common anywhere ("*D. Daucus*, a native of North America, being placed for it"—according to Mr. Stephens—"in collections"), perhaps I may be allowed to mention that a beautiful and perfect specimen of it was secured in my garden, on the 15th inst., by my little son, William Cecil. He was attracted to its resting-place in a wigelia bush by the flight there of a common gamma, and to his credit, inclosed it gently in his hand without the slightest injury—a prize indeed for a collector eight years old!

A specimen was also sent my daughter some months ago, from Porto Fino on the Riviera di Levante, by Mr. Robert Macdonald, but it was unfortunately wrecked in the post.

Bregner, Bournemouth, August 18 HENRY CECIL

The Recent Hail-storm

I INCLOSE a tracing of a broken window-pane—one of the the numerous cases of damage caused by the hail-storm on the morning of the 3rd inst. in this place. I almost fear the subject is one unworthy the attention of your readers, but I am curious to know what relation the space cut out may bear to the size of the hailstone causing it; and whether the clean and regular opening made would indicate an almost horizontal direction of the blow, as in the case of a bullet.

Observations of the extreme dimensions of the hailstones on that occasion are various among my neighbours, but one so large as 3½ inches seems incredible; and that one approaching such a size should strike a window at a right angle appears also improbable.

CHAS. FREDK. WHITE

42, Windsor Road, Ealing, August 20

OUR ASTRONOMICAL COLUMN

THE WASHINGTON CATALOGUE.—A second edition, as it is termed, of this extensive and useful work has been published, and will be found to be an even more important aid to the practical astronomer than the former one, which appeared as an appendix to the Washington volume for 1871, and to which reference has been made in this column as the "Washington General Catalogue." Like the first edition, it was prepared for publication by the late Prof. Yarnall, who died suddenly after a few hours' illness on February 27, having been an astronomer at the United States Naval Observatory for twenty-six years. In a note prefixed to this second edition, Admiral Rodgers, the present superintendent of the Observatory, handsomely acknowledges the extent and value of Prof. Yarnall's labours. A large majority of the observations upon which the catalogue is founded were made by him, as well as the computations, and the first printing of the work was executed under his immediate direction. It is stated that "the completed volume only reached him when he was already unconscious—an hour before his death. Astronomers will recognise in this volume not only a work of exceeding usefulness to them, but also a fitting memorial coming at the close of the long professional life of its author."

As was explained in the introduction to the former edition, the stars forming the catalogue consist mainly of stars used in observations with the zenith telescope, in the U.S. Army Surveys, in the lists of the Coast Survey, and many of Lacaille's stars mostly observed by Lacaille only. But there is a great addition of small stars, the positions of which were required for the reduction of the observations made by the late Mr. James Ferguson during the years that he was so industriously and effectively observing with the equatorial. As a whole, therefore, the catalogue is a very miscellaneous one. The first edition contained 10,658 stars, with a number of cases, however, where the star had been observed only in one element, and included objects observed during the years 1845 to 1871. The new edition contains the results of observations to 1877, and includes 11,103 stars; the mean places are for the beginning of the year 1860, but it is to be borne in mind that they do not include any effect of proper motion from the mean date of observation, which is always given, to that general epoch. The annual precessions are annexed, without secular variation.

Like other publications of the U.S. National Observatory, the new Washington catalogue appears to have been most liberally circulated amongst astronomers.

NEW COMETS.—On August 21 a telescopic comet was discovered at Pola by Herr Palisa; its position at 10h. 26m. M.T. was in right ascension 150° 35′ and declination + 49° 6′; daily motion in right ascension 1° 34′ increasing, and in declination 3 minutes diminishing; it was small but bright.

A second comet was discovered on August 24 at the Imperial Observatory, Strassburg, by Dr. Ernst Hartwig; it was then very faint and about $1\frac{1}{2}$ minutes in diameter. The following elements and ephemeris have been calculated by Dr. Hartwig, from the Strassburg observations on August 24 and 28, and one at Leipsic on August 26:—

Perihelion passage August 26·4661 M.T. at Berlin.

	° ′	
Longitude of perihelion	309 56·3	M.Eq. 1879·0.
,, ascending node ...	28 12·7	
Inclination	71 55·0	
Logarithm of perihelion distance	9·99056	

Motion—retrograde.

It will be found that these elements have no resemblance to those of any comet at present in our catalogues.

The following positions are for Berlin midnight:—

	Right Ascension. h. m. s.	Declination North. ° ′	Log. distance from Earth.	Sun.
Sept. 5	13 34 9	42 50·3	0·1055	9·9973
9	13 46 19	37 37·8	0·1314	0·0036
13	13 55 44	32 57·2	0·1577	0·0116
17	14 3 20	28 46·5	0·1834	0·0212
21	14 9 38	25 2·6	0·2081	0·0320
25	14 15 3	21 42·2	0·2315	0·0439
29	14 19 47	18 41·8	0·2535	0·0567

TO ASTRONOMERS

THE United States Naval Observatory will gratefully receive for its Library *separate copies* or *reprints* of memoirs published in the Transactions of learned societies or in journals. The volumes of Transactions are regularly received, but often many months after the reprints of particular papers, which are, therefore, especially valued.

It is also requested that all communications of this nature, and all correspondence relating to them, may be addressed to The Library, U.S. Naval Observatory, Washington, U.S.A.

Agents of the Smithsonian Institution abroad will receive large parcels for transmission. Smaller ones will be received more quickly if they are sent by post.

As far as possible the publications of the Observatory will be distributed to all working astronomers.

JOHN RODGERS,
Rear Admiral, U.S.N., Superintendent
Naval Observatory, Washington, D.C., August 18

GEOGRAPHICAL NOTES

THE Permanent Commission of the International Geodetic Association, presided over by General Ibañez, has decided to meet on the 16th inst. at Geneva, on the invitation which has been addressed to it by the Government of the little republic. The first official sitting is to be at 2 o'clock, on the 16th, at the Hotel de Ville of Geneva, in the room known as "the Alabama." In the evening Prof. E. Plantamour will hold a reception. The official sittings will continue daily at 10 A.M., in the same room, to the end of the week, interrupted on the 18th by a procession of steamers on the lake, which will occupy the whole of the day. On the evening of the 17th the Commissioners are invited to dine by the Council of the State of Geneva, and on the afternoon of the 19th there will be a reception at Sécheron by Prof. Plantamour. The programme of the session comprises: The reports of the Permanent Commission and the Central Bureau, the report of the Commission appointed at Hamburg in 1877 to consider the proposals of Lieut.-Col. Adan; the choice of the place of meeting of the sixth conference, and the appointment of special reporters to record the proceedings (1) As to determinations of latitude, longitude, and azimuth; (2) Triangulations and calculations of compensation of the networks; (3) Levelling operations and result of mareographic operations; (4) Measurements of the intensity of gravitation; (5) Publications relating to the measurement of degrees in Europe.

THE eminent African traveller, Dr. Junker, intends to start for Africa during this month. His first object is to reach Monbutta, which is to form the basis for his further investigations.

THE *Daily News* Lisbon correspondent telegraphs on September 2, that official news has arrived which states that on July 24 the explorers Ivens and Capello were in the district called Duque de Braganza. At the last session of the Geographical Society it was stated that the explorers were unable to continue their journey through want of means. The president promised to ask the Government to send them assitance. It will be remembered that Ivens and Capello started with Major Pinto.

WE find in the *Isvestia* of the Russian Geographical Society an interesting note by M. Potanin on the eastern Altai Mountains. Until 1869 these highlands were quite unknown, and even after the recent explorations of MM. Matusovsky and Sosnovsky it was considered that the Altai range did not go east of the meridian of Kobdo, where geographers, according to the map of Klaproth, supposed the existence of low hills which connected the Altai with the Tian Shan. Now M. Potanin proves that the Altai range goes further east, at least to the meridian of Lake Orok-nor, and that it is separated on its whole length by the Gobi steppe from the Tian Shan mountains. The altitude of the mountain passes in the parts visited by M. Potanin reaches as much as 8,000 feet. The eastern parts of the Altai mountains are rather dry, and forests in this part of the range are rather scarce.

THE same number of the *Isvestia* of the Russian Geographical Society contains an interesting note on the levelling accomplished during the last three years by the Russian General Staff on several lines of railways in Western Russia. The results are very satisfactory, as the probable error of this topographical levelling (with level and rule) does not exceed ± 2 inches on a distance of 100 versts (67 miles), *i.e.*, less than half the probable error of the best geodetical levellings. These levellings have brought to light a very interesting circumstance, namely, that the average level of the sea at Cronstadt is 13·2 ± 3·3 inches higher than at Dünamünde; the distance between the two towns being 240 miles. The Prussian levellings prove that the level of the Baltic is 20 inches higher at Kiel than at Memel.

CAPT. HOWGATE writes to us that he is preparing to send an expedition to the North Pole next year, independently of the course to be taken by Congress next session. A ship fitted by him will start for Lady Franklin Bay, even if Congress leaves him unassisted.

NOTES

THE Central Meteorological Office of Italy (the Collegio Romano) has just issued the third part of a most useful series, forming one volume of 282 pp., imperial 8vo. (Imprimerie Héritiers Botta, Rome, 1879), which will be of great service to meteorologists generally. They contain a translation, in French, of all the Reports (*in extenso* or abridged) prepared upon the different questions comprised in the Programme of the Second International Meteorological Congress held at Rome in April of this year, together with many other papers communicated to the Congress. The work has been undertaken with the view of presenting to meteorologists, not only the whole of the questions which have been discussed by the Congress, but also the *ensemble* of the experiments and documents which have formed, so to speak, the basis of each discussion, and which represent, at the same time, the opinion of the distinguished men from the whole of Europe upon the most important points of international meteorology. The translation has been carried out under the able superintendence of Prof. Guido Gras i, director of the Roman Central Office, and we congratulate that office upon the careful translation of the reports from the various languages and upon their speedy issue in one convenient volume.

OUR readers will be pleased to learn that Prof. Huxley's Introductory Primer to Macmillan's series of Science Primers will probably be published during the autumn; a considerable portion of it is already in type.

THE inauguration of Arago's statue will have the *éclat* of a national *fête*. The Municipal Council of Paris, of which Arago was an active member during Louis Philippe's reign, will send a deputation. The Bureau des Longitudes, the Observatory of Paris, and the Academy of Sciences, institutions which for years owed their lustre to the great Arago, are sending special representatives delegated for the purpose. M. Etienne Arago, the younger brother of the departed astronomer, a dramatic author, and M. Emmanuel Arago, his son, an influential member of the Senate, will be present at the ceremony, and will deliver addresses.

As will be seen from our British Association Reports, the Zoological Station at Naples has undertaken the publication of a new Zoological Record, in which equal attention will be paid to all departments of zoology. A large staff of zoologists of various nationalities will act as recorders, under the editorship of Prof. J. V. Carus, of Leipzig; and the first volume, dealing with the literature of the current year will appear in 1880. All those engaged in zoological work on any group of the animal kingdom are invited to send a copy of their papers to Prof. J. V. Carus, Leipzig, Querstrasse, 30; and to write on the address "for the Jahresbericht." Papers so sent will be distributed by Prof. Carus amongst the recorders, and after being abstracted for the Record, will be deposited in the library of the Zoological Station at Naples.

THE St. Petersburg Society of Naturalists has undertaken the publication of a complete Ornithology of Northern Russia. All who possess any data on that subject, or collections of birds, are requested to communicate them to "the St. Petersburg Society of Naturalists, at the University of St. Petersburg."

M. DOKUCHAIEFF, who was sent by the St. Petersburg Society of Naturalists for the exploration of the river and lacustrine quaternary deposits on the banks of the Oka, has discovered at the confluence of this river with the Frubesh, an immense quantity of stone implements. The dunes on the banks of the Oka in the neighbourhood of Kasimov town have also yielded a good many remains of prehistoric man. But the spot richest in remains is undoubtedly that five miles distant from Moorom town, where M. Dokuchaieff has found a remarkable variety of stone arrows, knives, and needles. As to the pieces, of wood which are very common in the blue clays of fluvio-lacustrine origin, and which were considered as remains of lacustrine dwellings, these are simply remains of forests which formerly covered all these deposits.

MR. CROOKES' admirable set of instruments for exhibiting the properties of radiant matter will be lectured upon at the Sorbonne at the beginning of next October, at the inauguration of the Autumn term of the Academy of Sciences.

ON October 6 next, a new Polytechnic Institution will be inaugurated at Hanover. The new building has recently been completed, and no cost has been spared to render it worthy to rank amongst the most complete and extensive buildings of the kind. Deputations from all the other polytechnic high school of Germany will participate in the inauguration-festivities.

THE death is announced of Dr. Otto Funke, Professor of Physiology at the University of Freiburg im Breisgau (Baden). Dr. Funke was an eminent physiologist, and lived at Leipzig for many years previous to his call to Freiburg. He died on August 16, at the age of fifty-one years.

THE Congress of German Viticulturists is now meeting at Coblenz, and is discussing a number of viticultural questions of importance, including, of course, the much-ventilated phylloxera question. At the same place a meeting of Rhenish agriculturists will take place between September 7 and 10, accompanied by an agricultural exhibition.

THE Zoological Section of the Westphalian Provincial Society for Arts and Sciences had an interesting exhibition at the Zoological Gardens of Münster from August 17 to August 24 last. It consisted exclusively of invertebrate animals, illustrations of their habits and specimens of their products. The exhibition comprised insects (bees, beetles, butterflies, flies, grasshoppers, &c.), centipedes, spiders, crustaceans, annelids, molluscs (cephalopoda, gasteropoda, conchifera), echinoderms (holothuriæ, echinoidea, asteroidea), cœlenterata (medusæ), polyps, sponges, and infusoria. Most of the animals were represented in living as well as preserved specimens.

DURING the second week in August the German Anthropological Society met at Strasburg, under the presidency of Prof. Fraas. 164 members were present. Amongst the numerous interesting papers read we notice the following:—On the prehistoric map of Southern Germany and Eastern France, by Herr von Troeltsch; Professors Oehlenschlaeger (Munich) and Wagner (Karlsruhe) spoke on the same subject; Prof. Schaaffhausen (Bonn) lectured on skull measurements; Dr. Much (Vienna), on prehistoric traces of copper-mining; Prof. Klopfleisch (Jena), on his own excavations in Thuringia; a specially interesting papers was that by Herr Fischer (Freiburg), on the method of determining the age of stone weapons and utensils. Other papers were read by Dr. Gross (Naefels), on the pile-dwellings in the Biel Lake; Dr. Krause (Hamburg), on artificial alterations of the skulls of the natives of the New Hebrides; Dr. Mehlis (Tückheim), on the excavations at Limburg; Dr. Hook, on the stone age in Egypt. The next meeting of the Society will take place at Berlin, under the presidency of Prof. Virchow.

THE International Society for the prevention of the pollution of rivers, the soil, and the atmosphere, will hold its third meeting at Baden-Baden on the 16th and 17th inst.

AT Rome a new Society for furthering the introduction of cremation was formed on August 12 last. Many eminent medical men are members.

NEWS from the village of Havnen, Iceland, states that a violent volcanic eruption was observed at the end of May in the vicinity of the so-called Geisfugle shears, in the south-west of the island. It is curious that about the same time the eruption of Mount Etna took place.

THE first volume of a remarkable botanical work entitled "Versuch einer Entwickelungsgeschichte der Pflanzenwelt, insbesondere der Florengebiete seit der Tertiärperiode," by Dr. Ad. Engler, of Kiel, will be published next month by W. Engelmann, of Leipzig.

THE Rev. S. J. Whitmee informs us that he has received letters from the Society Islands assuring him there was no such devastation of the islands of Raiatea and Borabora (Porapora) by earthquake as was reported by Capt. Evers, and which is mentioned in the article "On Volcanic Phenomena during 1878," in NATURE, vol. xx. p. 378. No reference, he reminds us, is made in the article to the pumice and torn-up trees, carried apparently from the island of Birara, south-east to and beyond the Ellia Atolls, which he reported to us some months ago.

A CORRESPONDENT informs us that the observer of the Scottish Meteorological Society in Ireland reports fine weather there in June and July, with little or no rain, by which the pastures have suffered severely; but the fishing at most places is good, in direct contrast to what has prevailed in the British Isles.

THE City and Guilds Institute having granted 400*l*. per annum for purposes of technical education at University College, London, have resolved that the grant be appropriated in maintaining the chair of Chemical Technology, and that of Engineering and Mechanical Technology. The Professor of Chemical Technology, Dr. Charles Graham, has announced "Technical Education" as the subject of his public lecture at the College on October 1.

AN experiment before the Parisian press was tried on August 28, in the large room of the St. Lazare Railway Station, by a company started for establishing a Central Hall of Telephony under the Edison patent. The experiments were found quite satisfactory for musical instruments, but not so for the ordinary voice. The Company has received from the Government authority to inaugurate its operations, and a sum of 2*l*. per month is required for the use of a wire with the right of interchanging communications with any person having a wire directed to the Central Hall.

A SPECIAL excursion tour for members of the French Parliament has been organised to Algiers. The members will start in this month, and devote their vacation to the study of the land on behalf of which they are to legislate. The Municipal Council of Algiers has voted a sum of 200*l*. for the reception of their legislators.

WE take the following statements from a preliminary communication made to the Vienna Academy of Sciences by Herr G. L. Ciamician, with reference to the further results of his spectroscopic investigations:—"If the spectra of the metals of the alkaline earths are produced by the spark of an induction apparatus (with inserted Leyden jar) passing between the metals as electrodes in a hydrogen tube, then spectra are obtained which show the homology of the spectral lines in a most beautiful manner. The spectrum of magnesium, however, cannot be compared to the spectra thus obtained because it does not contain the less refrangible lines. If, however, the Leyden jar be removed, or if a weaker battery and a smaller induction coil be employed, all red and yellow lines in the spectra of calcium and strontium will disappear and spectra are obtained which are extremely similar to that of magnesium. If the less refrangible part of the spectrum of the group of alkaline earth-metals, which therefore is only visible at a high temperature (corresponding to a high electric tension), be compared to the less refrangible half of the complete oxygen spectrum, the remarkable similarity of these two spectrum-halves will at once strike the observer. The inference to be drawn from these facts would seem to be that the spectrum of the group of alkaline earth-metals is composed of the magnesium spectrum and of the less refrangible half of the oxygen spectrum.

A NUMBER of interesting observations made during a recent cruise of the French frigate *La Magicienne*, to various parts of the Pacific, chiefly formed the subject of a recent paper by Admiral Serres to the French Academy. Among other points attention had been drawn while at San Francisco to the swift tall-masted clipper ships which convey wheat to the European market. The modern practice of increasing the high sails at the expense of the lower is justified by science. During the voyage of *La Magicienne*, a Robinson anemometer was observed daily at an altitude of 8 metres, and twice every day the same instrument was observed at 36 metres. With very rare exceptions the velocity of the wind was always found much greater in the latter case than in the former. The average ratio deduced from thousands of observations was about 12 to 10. One can thus see the reason of seeking motive force in the upper regions.

PURSUING his researches on the scintillation of stars, M. Montigny shows, in a recent note to the Belgian Academy, that the following conclusion may be formulated:—When, in those observations where the colours characterising the phenomenon are distinctly separated, the blue tint predominates or is found in excess, rain may be expected, if it have not already come. There is great probability that the rain will be the more persistent and plentiful the more marked the predominance of blue. M. Montigny recalls the observations of P. Secchi, M. Janssen, and Prof. Piazzi Smyth, according to which the telluric lines of the solar spectrum increase in number and intensity in circumstances where the solar rays encounter a larger quantity of aqueous vapour in the atmosphere, either as the sun nears the horizon, or as the humidity of the air increases. Prof. Smyth bases predictions of rain on certain telluric bands in the spectrum, which he calls *rain-bands*. M. Montigny thinks there is no doubt that similar phenomena of absorption are produced in the case of certain rays emanating from the stars, where these traverse more or less moist layers of our atmosphere.

AN apparatus called the "telephone syren" has been recently described to the Schleswig-Holstein Society of Natural Sciences by Herr Karsten. On a circular disk 10 ctm. in diameter are fixed radially twenty-four small magnetic bars. This disk is rapidly rotated before a Bell telephone deprived of the iron plate. Where the same poles of the magnets are all directed outwards, one hears a certain tone; if the poles alternate, the lower octave is heard. If the succession of poles at the border of the disk be (say) N N S, there are heard three tones: one corresponding to the interval N N, one an octave lower corresponding to N S N, and a third combination-tone of three times the time of vibration of the highest, corresponding to the return, each time, of the first N. The vibration-numbers are thus as 3 : 2 : 1. Similar experiments may be made with the combination N N N S, where tones are obtained with the relation 4 : 2 : 1.

THE additions to the Zoological Society's Gardens during the past week include a Vervet Monkey (*Cercopithecus lalandii*) from South Africa, presented by Mr. W. T. Millar; a Rose Hill Parrakeet (*Platycercus eximius*) from New South Wales, presented by Mr. Arthur Stirling; a Common Kestrel (*Tinnunculus alaudarius*), British, presented by Mr. R. Moon; a Chequered Elaps (*Elaps lemniscatus*) from South America, presented by Dr. A. Stradling; an Annulated Snake (*Leptodira annulata*) from Colon, presented by Mr. R. F. Davis; three Horned Lizards

(*Phrynosoma cornutum*) from Texas, presented by Mr. Ernest E. Sabel; a Sulphur-breasted Toucan (*Ramphastos carinatus*) three Black-necked Stilt Plovers (*Himantopus nigricollis*), two Cayenne Lapwings (*Vanellus cayennensis*) from South America, a Slow Loris (*Nycticebus tardigradus*) from Malacca, a Radiated Tortoise (*Testudo radiata*) from Madagascar, two Electric Silurus (*Malapterurus beninensis*) from West Africa, purchased; a Squirrel-like Phalanger (*Belideus sciurea*), born in the Gardens.

ON RADIANT MATTER[1]

II.

Radiant Matter exerts strong Mechanical Action where it Strikes

We have seen, from the sharpness of the molecular shadows, that radiant matter is arrested by solid matter placed in its path.

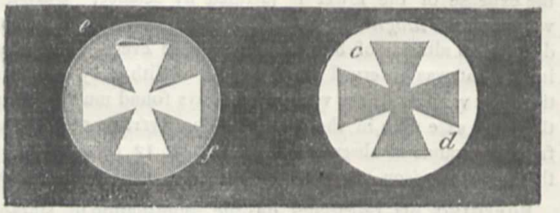

FIG. 10.

If this solid body is easily moved the impact of the molecules will reveal itself in strong mechanical action. Mr. Gimingham has constructed for me an ingenious piece of apparatus which when placed in the electric lantern will render this mechanical action visible to all present. It consists of a highly-exhausted glass tube (Fig. 11), having a little glass railway running along it from one end to the other. The axle of a small wheel revolves on the rails, the spokes of the wheel carrying wide mica paddles. At each end of the tube, and rather above the centre, is an aluminium pole, so that whichever pole is made negative the stream of radiant matter darts from it along the tube, and striking the upper vanes of the little paddle-wheel, causes it to turn round and travel along the railway. By reversing the poles I can arrest the wheel and send it the reverse way, and if I gently incline the tube the force of impact is observed to be sufficient even to drive the wheel up-hill.

This experiment therefore shows that the molecular stream

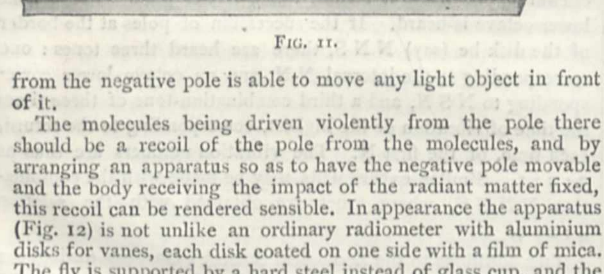

FIG. 11.

from the negative pole is able to move any light object in front of it.

The molecules being driven violently from the pole there should be a recoil of the pole from the molecules, and by arranging an apparatus so as to have the negative pole movable and the body receiving the impact of the radiant matter fixed, this recoil can be rendered sensible. In appearance the apparatus (Fig. 12) is not unlike an ordinary radiometer with aluminium disks for vanes, each disk coated on one side with a film of mica. The fly is supported by a hard steel instead of glass cup, and the needle-point on which it works is connected by means of a wire with a platinum terminal sealed into the glass. At the top of the radiometer bulb a second terminal is sealed in. The radiometer therefore can be connected with an induction-coil, the movable fly being made the negative pole.

For these mechanical effects the exhaustion need not be so high as when phosphorescence is produced. The best pressure for this electrical radiometer is a little beyond that at which the dark space round the negative pole extends to the sides of the glass bulb. When the pressure is only a few millims. of mercury, on passing the induction current a halo of velvety violet light forms on the metallic side of the vanes, the mica side remaining dark. As the pressure diminishes, a dark space is seen to separate the violet halo from the metal. At a pressure of half a millim. this dark space extends to the glass, and rotation commences. On continuing the exhaustion the dark space further widens out and appears to flatten itself against the glass, when the rotation becomes very rapid.

Here is another piece of apparatus (Fig. 13) which illustrates

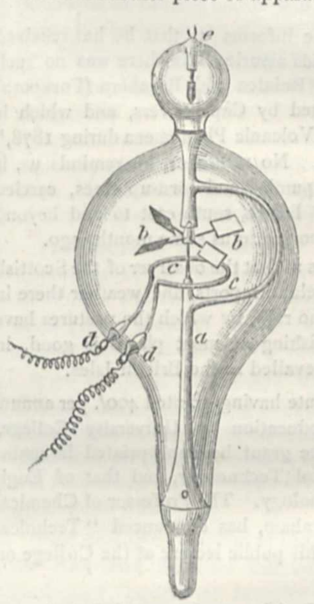

FIG. 12.

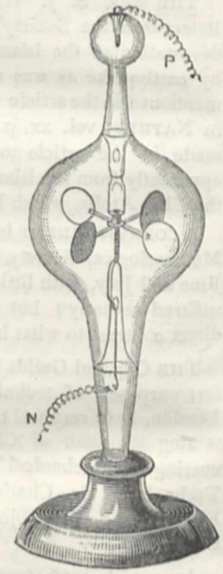

FIG. 13.

the mechanical force of the radiant matter from the negative pole. A stem (*a*) carries a needle-point in which revolves a light mica fly (*b b*). The fly consists of four square vanes of thin clear mica, supported on light aluminium arms, and in the centre is a small glass cap which rests on the needle-point. The vanes are inclined at an angle of 45° to the horizontal plane. Below the fly is a ring of fine platinum wire (*c c*), the ends of which pass through the glass at *d d*. An aluminium terminal (*e*) is sealed in at the top of the tube, and the whole is exhausted to a very high point.

By means of the electric lantern I project an image of the vanes on the screen. Wires from the induction-coil are attached,

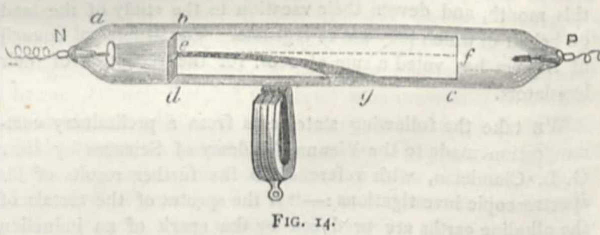

FIG. 14.

so that the platinum ring is made the negative pole, the aluminium wire (*e*) being positive. Instantly, owing to the projection of radiant matter from the platinum ring, the vanes rotate with extreme velocity. Thus far the apparatus has shown nothing more than the previous experiments have prepared us to expect; but observe what now happens. I disconnect the induction-coil altogether, and connect the two ends of the platinum wire with a small galvanic battery; this makes the ring *c c* red-hot, and under this influence you see that the vanes spin as fast as they did when the induction-coil was at work.

Here, then, is another most important fact. Radiant matter in these high vacua is not only excited by the negative pole of an induction-coil, but a hot wire will set it in motion with force sufficient to drive round the sloping vanes.

[1] A lecture delivered to the British Association for the Advancement of Science, at Sheffield, Friday, August 22, 1879, by William Crookes, F.R.S. Continued from p. 423.

Radiant Matter is deflected by a Magnet

I now pass to another property of radiant matter. This long glass tube (Fig. 14), is very highly exhausted; it has a negative pole at one end (*a*) and a long phosphorescent screen (*b*, *c*) down the centre of the tube. In front of the negative pole is a plate of mica (*b*, *d*) with a hole (*e*) in it, and the result is, when I turn on the current, a line of phosphorescent light (*e*, *f*) is projected along the whole length of the tube. I now place beneath the tube a powerful horse-shoe magnet: observe how the line of light (*e*, *g*) becomes curved under the magnetic influence waving about like a flexible wand as I move the magnet to and fro.

This action of the magnet is very curious, and if carefully followed up will elucidate other properties of radiant matter. Here (Fig. 15) is an exactly similar tube, but having at one end a small potash tube, which if heated will slightly injure the vacuum. I turn on the induction current, and you see the ray of radiant matter tracing its trajectory in a curved line along the screen, under the influence of the horse-shoe magnet beneath. Observe the shape of the curve. The molecules shot from the negative pole may be likened to a discharge of iron bullets from a mitrailleuse, and the magnet beneath will represent the earth curving the trajectory of the shot by gravitation. Here on this luminous screen you see the curved trajectory of the shot accurately traced. Now suppose the deflecting force to remain constant, the curve traced by the projectile varies with the velocity. If I put more powder in the gun the velocity will be greater and the trajectory flatter, and if I interpose a denser resisting medium between the gun and the target, I diminish the velocity of the shot, and thereby cause it to move in a greater curve and come to the ground sooner. I cannot well increase before you the velocity of my stream of radiant molecules by putting more

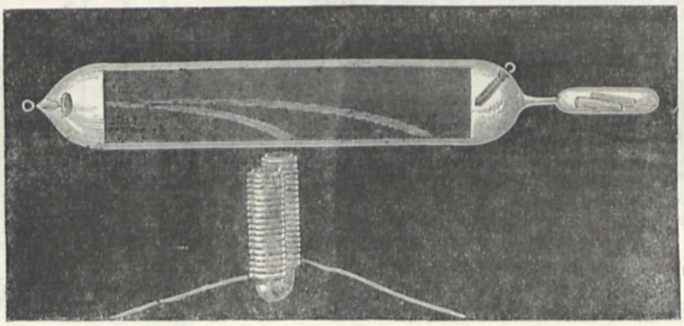

FIG. 15.

powder in my battery, but I will try and make them suffer greater resistance in their flight from one end of the tube to the other. I heat the caustic potash with a spirit-lamp and so throw in a trace more gas. Instantly the stream of radiant matter responds. Its velocity is impeded, the magnetism has longer time on which to act on the individual molecules, the trajectory gets more and more curved, until, instead of shooting nearly to the end of the tube, my molecular bullets fall to the bottom before they have got more than half-way.

It is of great interest to ascertain whether the law governing the magnetic deflection of the trajectory of radiant matter is the same as has been found to hold good at a lower vacuum. The experiments I have just shown you were with a very high vacuum. Here is a tube with a low vacuum (Fig. 16). When I turn on the induction spark, it passes as a narrow line of violet light

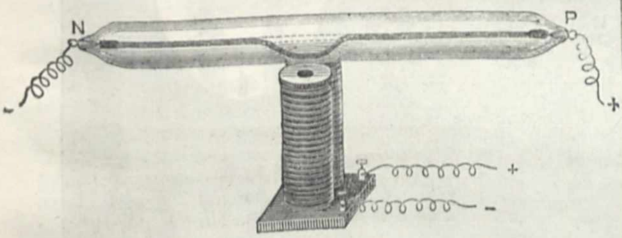

FIG. 16.

joining the two poles. Underneath I have a powerful electro-magnet. I make contact with the magnet, and the line of light dips in the centre towards the magnet. I reverse the poles, and the line is driven up to the top of the tube. Notice the difference between the two phenomena. Here the action is temporary. The dip takes place under the magnetic influence; the line of discharge then rises and pursues its path to the positive pole. In the high exhaustion, however, after the stream of radiant matter had dipped to the magnet, it did not recover itself, but continued its path in the altered direction.

By means of this little wheel, skilfully constructed by Mr. Gimingham, I am able to show the magnetic deflection in the electric lantern. The apparatus is shown in this diagram (Fig. 17). The negative pole (*a*, *b*) is in the form of a very shallow cup. In front of the cup is a mica screen (*c*, *d*), wide enough to intercept the radiant matter coming from the negative pole. Behind this screen is a mica wheel (*e*, *f*) with a series of vanes, making a sort of paddle-wheel. So arranged, the molecular rays from the pole *a b* will be cut off from the wheel, and will not produce any movement. I now put a magnet, *g*, over the tube, so as to deflect the stream over or under the obstacle *c*, *d*, and the result will be rapid motion in one or the other direction, according to the way the magnet is turned. I throw the image of the apparatus on the screen. The spiral lines painted on the wheel show which way it turns. I arrange the magnet to draw the molecular stream so as to beat against the upper vanes, and the wheel revolves rapidly as if it were an over-shot water-wheel. I turn the magnet so as to drive the radiant

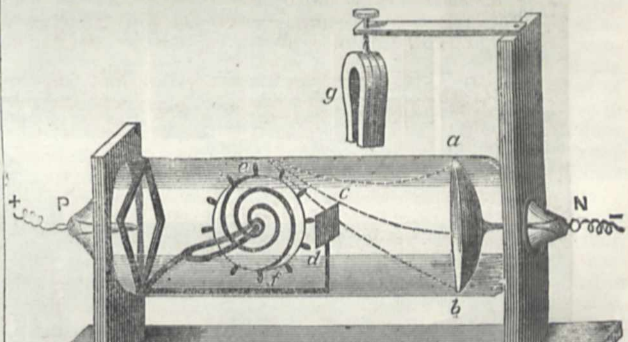

FIG. 17.

matter underneath; the wheel slackens speed, stops, and then begins to rotate the other way, like an under-shot water-wheel. This can be repeated as often as I reverse the position of the magnet.

I have mentioned that the molecules of the radiant matter discharged from the negative pole are negatively electrified. It is probable that their velocity is owing to the mutual repulsion between the similarly electrified pole and the molecules. In less high vacua, such as you saw a few minutes ago (Fig. 16), the discharge passes from one pole to another, carrying an electric current, as if it were a flexible wire. Now it is of great interest to ascertain if the stream of radiant matter from the negative pole also carries a current. Here (Fig. 18) is an apparatus which will decide the question at once. The tube contains two negative terminals (*a*, *b*) close together at one end, and one positive terminal (*c*) at the other. This enables me to send two streams of radiant matter side by side along the phosphorescent screen—or by disconnecting one negative pole, only one stream.

If the streams of radiant matter carry an electric current they will act like two parallel conducting wires and attract one

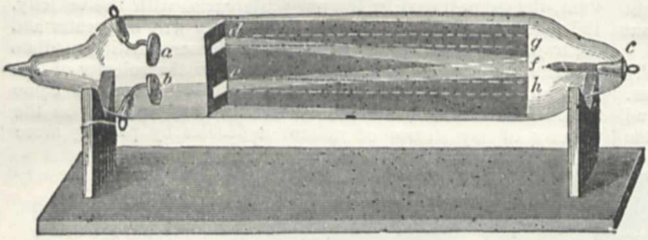

Fig. 18.

another; but if they are simply built up of negatively electrified molecules they will repel each other.

I will first connect the upper negative pole (*a*) with the coil, and you see the ray shooting along the line *d*, *f*. I now bring the lower negative pole (*b*) into play, and another line (*e*, *h*) darts along the screen. But notice the way the first line behaves; it jumps up from its first position, *d f*, to *d g*, showing that it is repelled, and if time permitted I could show you that the lower ray is also deflected from its normal direction: therefore the two parallel streams of radiant matter exert mutual repulsion, acting not like current carriers, but merely as similarly electrified bodies.

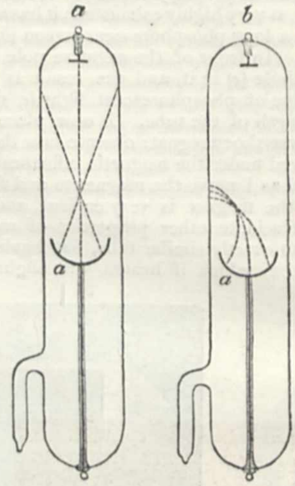

Fig. 19.

Radiant Matter produces Heat when its Motion is arrested

During these experiments another property of radiant matter has made itself evident, although I have not yet drawn attention

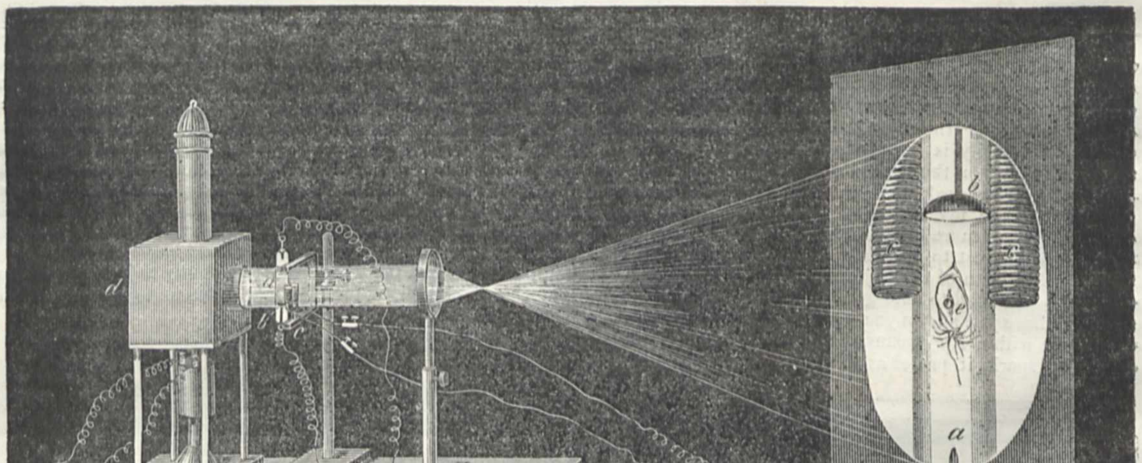

Fig. 20.

to it. The glass gets very warm where the green phosphorescence is strongest. The molecular focus on the tube, which we saw earlier in the evening (Fig. 8) is intensely hot, and I have prepared an apparatus by which this heat at the focus can be rendered apparent to all present.

I have here a small tube (Fig. 19, *a*) with a cup-shaped negative pole. This cup projects the rays to a focus in the middle of the tube. At the side of the tube is a small electro-magnet, which I can set in action by touching a key, and the focus is then drawn to the side of the glass tube (Fig. 19, *b*). To show the first action of the heat I have coated the tube with wax. I will put the apparatus in front of the electric lantern (Fig. 20, *d*), and throw a magnified image of the tube on the screen. The coil is now at work, and the focus of molecular rays is projected along the tube. I turn the magnetism on, and draw the focus to the side of the glass. The first thing you see is a small circular patch melted in the coating of wax. The glass soon begins to disintegrate, and cracks are shooting star-wise from the centre of heat. The glass is softening. Now the atmospheric pressure forces it in, and now it melts. A hole (*e*) is perforated in the middle, the air rushes in, and the experiment is at an end.

I can render this focal heat more evident if I allow it to play on a piece of metal. The bulb (Fig. 21) is furnished with a negative pole in the form of a cup (*a*). The rays will therefore be projected to a focus on a piece of iridio-platinum (*b*) supported in the centre of the bulb.

I first turn on the induction-coil slightly, so as not to bring out its full power. The focus is now playing on the metal, raising it to a white heat. I bring a small magnet near, and you see I can deflect the focus of heat just as I did the luminous focus in the other tube. By shifting the magnet I can drive the focus up and down, or draw it completely away from the metal, and leave it non-luminous. I withdraw the magnet, and let the molecules have full play again; the metal is now white hot. I increase

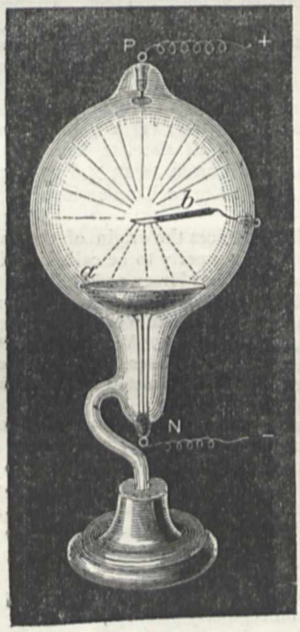

FIG. 21.

the intensity of the spark. The iridio-platinum glows with almost insupportable brilliancy, and at last melts.

The Chemistry of Radiant Matter

As might be expected, the chemical distinctions between one kind of radiant matter and another at these high exhaustions are difficult to recognise. The physical properties I have been elucidating seem to be common to all matter at this low density. Whether the gas originally under experiment be hydrogen, carbonic acid, or atmospheric air, the phenomena of phosphorescence, shadows, magnetic deflection, &c., are identical, only they commence at different pressures. Other facts, however, show that at this low density the molecules retain their chemical characteristics. Thus by introducing into the tubes appropriate absorbents of residual gas, I can see that chemical attraction goes on long after the attenuation has reached the best stage for showing the phenomena now under illustration, and I am able by this means to carry the exhaustion to much higher degrees that I can get by mere pumping. Working with aqueous vapour I can use phosphoric anhydride as an absorbent; with carbonic acid, potash; with hydrogen, palladium; and with oxygen, carbon, and then potash. The highest vacuum I have yet succeeded in obtaining has been the 1-20,000,000th of an atmosphere, a degree which may be better understood if I say that it corresponds to about the hundredth of an inch in a barometric column three miles high.

It may be objected that it is hardly consistent to attach primary importance to the presence of *Matter*, when I have taken extraordinary pains to remove as much matter as possible from these bulbs and these tubes, and have succeeded so far as to leave only about the one-millionth of an atmosphere in them. At its ordinary pressure the atmosphere is not very dense, and its recognition as a constituent of the world of matter is quite a modern notion. It would seem that when divided by a million, so little matter will necessarily be left that we may justifiably neglect the trifling residue and apply the term *vacuum* to space from which the air has been so nearly removed. To do so, however, would be a great error, attributable to our limited faculties being unable to grasp high numbers. It is generally taken for granted that when a number is divided by a million the quotient must necessarily be small, whereas it may happen that the original number is so large that its division by a million seems to make little impression on it. According to the best authorities, a bulb of the size of the one before you (13·5 centimetres in diameter) contains more than 1,000,000,000,000,000,000,000,000 (a quadrillion) molecules. Now, when exhausted to a millionth of an atmosphere we shall still have a trillion molecules left in the bulb—a number quite sufficient to justify me in speaking of the residue as *matter*.

To suggest some idea of this vast number I take the exhausted bulb, and perforate it by a spark from the induction-coil. The spark produces a hole of microscopical fineness, yet sufficient to allow molecules to penetrate and to destroy the vacuum. The inrush of air impinges against the vanes, and sets them rotating after the manner of a windmill. Let us suppose the molecules to be of such a size that at every second of time a hundred millions could enter. How long, think you, would it take for this small vessel to get full of air? An hour? A day? A year? A century? Nay, almost an eternity! A time so enormous that imagination itself cannot grasp the reality. Supposing this exhausted glass bulb, indued with indestructibility, had been pierced at the birth of the solar system; supposing it to have been present when the earth was without form and void; supposing it to have borne witness to all the stupendous changes evolved during the full cycles of geologic time, to have seen the first living creature appear, and the last man disappear; supposing it to survive until the fulfilment of the mathematician's prediction that the sun, the source of energy, four million centuries from its formation, will ultimately become a burnt-out cinder;[1] supposing all this—at the rate of filling I have just described, 100 million molecules a second—this little bulb even then would scarcely have admitted its full quadrillion of molecules.[2]

But what will you say if I tell you that all these molecules, this quadrillion of molecules, will enter through the microscopic hole before you leave this room? The hole being unaltered in size, the number of molecules undiminished, this apparent paradox can only be explained by again supposing the size of the molecules to be diminished almost infinitely—so that instead of entering at the rate of 100 millions every second, they troop in at a rate of something like 300 trillions a second. I have done the sum, but figures when they mount so high cease to have any meaning, and such calculations are as futile as trying to count the drops in the ocean.

In studying this fourth state of matter we seem at length to have within our grasp and obedient to our control the little indivisible particles which with good warrant are supposed to constitute the physical basis of the universe. We have seen that in some of its properties radiant matter is as material as this table, whilst in other properties it almost assumes the character of radiant energy. We have actually touched the borderland where matter and force seem to merge into one another, the shadowy realm between Known and Unknown which for me has always

[1] The possible duration of the sun from formation to extinction has been variously estimated by different authorities, at from 18 million years to 400 million years. For the purpose of this illustration I have taken the highest estimate.

[2] According to Mr. Johnstone Stoney (*Phil. Mag.*, vol. 36, p. 141), 1 c.c. of air contains about 1,000,000,000,000,000,000,000 molecules. Therefore a bulb 13·5 centims. diameter contains $13·5^3 \times 0·5236 \times$ 1,000,000,000,000,000,000,000 or 1,288,252,350,000,000,000,000,000 molecules of air at the ordinary pressure. Therefore the bulb when exhausted to the millionth of an atmosphere, contains 1,288,252,350,000,000,000 molecules, leaving 1,288,251,061,747,650,000,000,000 molecules to enter through the perforation. At the rate of 100,000,000 molecules a second, the time required for them all to enter will be

12,882,510,617,476,500 seconds, or
214,708,510,291,275 minutes, or
3,578,475,171,521 hours, or
149,103,132,147 days, or
408,501,731 years.

had peculiar temptations. I venture to think that the greatest scientific problems of the future will find their solution in this Border Land, and even beyond; here, it seems to me, lie Ultimate Realities, subtle, far-reaching, wonderful.

"Yet all these were, when no Man did them know,
Yet have from wisest Ages hidden beene;
And later Times thinges more unknowne shall show.
Why then should witlesse Man so much misweene,
That nothing is, but that which he hath seene?"

THE BRITISH ASSOCIATION

GENERAL satisfaction is expressed with the Sheffield meeting. The people of the town and district did their best, amid many difficulties, to give the members of the Association a hearty reception, and they succeeded. The excursions on Thursday were well attended, and those who took part in them seem to have enjoyed themselves. At the meeting of the General Committee, Swansea was selected as next year's place of meeting, with Prof. A. R. Ramsay as president; the date of meeting is August 25. A letter was read from the Archbishop of York, warmly urging upon the Association to meet in the archiepiscopal City in 1881, when, for some unaccountable reason, the jubilee is to be celebrated, as we have already said, in the fifty-first year of the Association's existence. As the result of the important discussion in Section F on science teaching in schools, a committee was appointed for the purpose of reporting, in addition to other matters, whether it is important that her Majesty's inspectors of elementary schools should be appointed with reference to their ability for examining on scientific specific subjects of the code, the committee to consist of Mr. Mundella, M.P., Mr. Shaw, Mr. Bourne, Mr. Jas. Heywood, Mr. Wilkinson, and Dr. J. H. Gladstone.

REPORTS

Report of the Committee on Erratic Blocks, presented by the Rev. H. W. Crosskey, F.G.S. (Abstract.)

Several contributions of interest and importance have been received respecting the position and distribution of erratic blocks.

A granite boulder 3 × 2·5 × 2 feet has been found by Mr. Hall, in the village of Bickington, parish of Fremington. There is no similar rock nearer than Lundy Island, twenty-five miles west-north-west from the boulder and Dartmoor, twenty-five miles south by east. Its height above the sea is 80 feet.

Among the most remarkable erratic blocks yet described in the midland district, are those reported upon Frankley Hill, at a height of 650 feet above the sea. They were examined by the writer in company with Prof. T. G. Bonney, and the following is a summary of the observations made:—

A section of drift beds is exposed in a cutting of the new Hales Owen Railway passing through Frankley Hill. The section is as follows:—Permian clay, sand of clayey texture, yellowish sand, greyish sandy clay with brinter pebbly clay, somewhat sandy. The heights of the clays and sands are very irregular throughout the section which is in itself about 60 feet in depth.

Fragments of permian sandstone (which is exposed in a part of the section) are scattered through the sands and clays, but erratic blocks are rare. Indeed, one only—a green-stone—was noticed in the cutting itself, although others doubtless occur.

No part of this section can be called a "boulder clay"—if by "boulder clay" be meant either a clay formed beneath land ice, or a clay carried away by an iceberg and deposited on the sea-bottom, as the berg melted or stranded.

The various sands and gravels have all the appearance of being a "wash" from older beds, effected during the depression and subsequent upheaval of the present land surface. They are neither compactly crowded with erratics, nor are fragments of local rocks heaped irregularly together, and grooved and striated. The way in which the pieces of native rock are scattered through the beds, does not indicate any other force than that which would be exerted by the ordinary "wash" of the waters during the movements just mentioned.

The presence of a few erratics shows that the *wash* must have taken place beneath the waters of a glacial sea, over which icebergs floated.

These beds appear to have been formed in the earlier rather than the later part of the glacial epoch. In a field *on the summit of the section* a large number of erratics are to be seen which have been taken from a recent surface-drain. Twenty of these boulders are felsite, two are basalt, one is a piece of vein-quartz, and one is a Welsh diabase. They constitute a group of allied rocks, evidently from one district. Probably they belong to the great Arenig dispersion. Two of the felsites close to the group are of considerable size, the larger being about 6 × 4 × 2 feet. Similar blocks may be traced to the summit of the hill. One felsite boulder opposite the Yew Trees is about 4·5 × 3 × 2 feet, and is partly buried in the ground.

The height of the boulders above the sea is remarkable, their highest level being 650 feet.

This indicates a corresponding depression of the land, since no Welsh glacier could have travelled over hill and down dale to this summit-level. To render any such glacier work conceivable, the Welsh mountains must have stood at a height beyond any point for which there is the slightest evidence.

This group of boulders on Frankley Hill appears to have been dropped by an iceberg travelling from Wales upon the top of the clays and sands exposed in the railway cutting at a time when the land was depressed at least 700 feet. In the clays and sands upon which the summit group of erratics rests, we must have beds belonging to an earlier date than the *close* of the glacial epoch; and the erratics in the cutting must be discriminated from those left at the higher level.

Some remarkable boulders were described from the neighbourhood of Wolverhampton: (1) a striated boulder of felsite 11 × 3 × 3 feet; (2) one of slate, broken into two parts, but which, when whole, measured 11·25 × 6·25 × 3·5 feet; (3) one of granite about 4·75 feet in each dimension, and weighing about three tons.

Mr. D. Mackintosh traces the origin of the so-called "greenstone" boulders (more properly to be called diorites or dolerites) around the estuaries of the Mersey and the Dee.

The area in which they are very much concentrated is intensely striated, and nearly all the striæ point divergently to the south of Scotland, *i.e.*, between N. 15° W. and N. 45° W.

A large "greenstone" boulder has been found at Crosby, resting on a perfectly flat glaciated rock surface, with striæ pointing N. 40° W.

Additional presumptions in favour of the Scottish derivation of these boulders may be found (1) in the fact that nearly all these boulders consist of basic rocks similar to some found in the south of Scotland, and (2) in the extent to which they are locally concentrated on the peninsula of Wirral and the neighbouring part of Lancashire. Many fresh greenstone boulders have been lately exposed in the newest Bootle Dock excavation. The largest is 6 × 4·5 × 3 feet, and was found on the surface of the upper boulder clay. As a rule these boulders are excessively flattened and regularly grooved.

Mr. J. R. Dakyns describes the occurrence of Shap granite boulders on the Yorkshire coast. There are several at Long Nab on the north side of the Nab; one of these measures 3 cubic feet. Others are on the north side of Cromer Point; south of Cromer Point there are more till you come nearly to Filey. There is one measuring 3 × 2·5 × 2 feet on the top of the cliff about a mile from Filey. It is probably practically undisturbed, for the ground slopes inland from the cliff, and therefore, if it has been turned up in ploughing and moved, it cannot have been moved far, for no one would take the trouble to cart a huge boulder far up-hill.

There are several boulders of Shap granite on the shore along the north of Filey Bay, but none along the south till one reaches Flamborough Head. Several occur along the shore between Flamborough Head and Flamborough south landing; one of these measures 36 cubic feet. One may be seen rather more than a mile south of Bridlington Quay, and doubtless they have travelled still further south, since there is one built into a wall at Hornsea.

The destruction of erratic blocks is going on so rapidly that the Committee invite continued contributions of information concerning them.

Report of the "Geological Record" Committee, by W. Whitaker, B.A., F.G.S.—Since the last meeting of the Association the third volume of the "Geological Record" has been published. This gives an account of books, papers, &c., on geology, mineralogy, and palæontology published at home and abroad during the year 1876. The fourth volume (for 1877) is in the press; and part of the MS. for the fifth volume (for 1878) is in hand. The average size of the three published volumes is 440 pages, each volume recording over 2,000 papers, &c.

Fifteenth Report of the Committee for Exploring Kent's Cavern, Devonshire. Drawn up by W. Pengelly, F.R.S.—Work during the past year has been carried on in the "High Chamber" and its branches. This chamber extends for about 53 feet in a north-westerly direction from the "Cave of Inscriptions." At its inner or north-western end it sends off two branches; the northern branch was excavated for about 12 feet, when the work was abandoned, as breccia, blocks of limestone, and crystalline stalagmite reached the roof and rendered further progress difficult and expensive. The "High Chamber" contains only breccia, the oldest mechanical deposit in the cavern, and the crystalline stalagmite which overlies it. Bones of bears and implements have been found in the breccia here, and some recent objects were found on or near the surface. The southern branch of the High Chamber is called the "Swallow Gallery," from a swallow-hole which occurs about 18 feet from the entrance. This has been explored for about 50 feet. It also contains only breccia, generally lying bare, but covered with crystalline stalagmite at the inner part of the chamber. Here too the remains consist chiefly of bear; a few implements have also been found. There were entrances to the cavern by the Swallow Gallery and through the swallow holes; but these were quite closed before the beginning of the "cave-earth era," and have since remained so. Excavations have also been made in Clinnick's Gallery; but here, as in former years, the number of "finds" has been small.

Prof. A. Leith Adams has availed himself of the collection of mammoth remains made during several years from Kent's Cavern, to illustrate his memoir for the Palæontological Society on "British Fossil Elephants." Extracts from this memoir are given in the report, and especial mention is made of a molar found in 1874 in the "Cave of Rodentia." Prof. Adams says:—"This tooth is one of the smallest milk-molars of any elephant with which I am acquainted, and is even more diminutive than the first milk-teeth of the Maltese pigmy elephants."

Report on the Miocene Flora, &c., of the North of Ireland, by W. H. Baily.—The plants occur, between two beds of basalt, in a deposit of brown and red bole, and immediately overlying a bed of pisolitic iron ore, which has been extensively worked. Twenty-five species of plants have been determined; they are most closely allied to the fossil flora of North Greenland, some of the forms also occurring at Bovey Tracy.

Sixth Report of a Committee consisting of Professors Herschel and Lebour, and Mr. J. T. Dunn, to determine the Thermal Conductivities of certain Rocks, showing especially the Geological Aspects of the Investigation.—The research and correspondence which it would require to complete a historical sketch of the attempts already made to determine by experiments the thermal conductivities of the most widely distributed terrestrial rocks, which the Committee proposed to prepare during the past year, are not so far advanced at present as to allow them to be comprehended in this year's Report. But the Committee hopes during the coming year by continuing its inquiries with the addition to its numbers of the names of Professors W. E. Ayrton and J. Perry, of the Imperial College of Engineering in Japan, to carry out the object of its undertaking, so as to exhibit the state of our knowledge of the data of thermal conductivity of those widespread kinds of rock which constitute the external materials of the globe.

The Committee has obtained during the past year some measurements of thermal conductivities both of rocks and ebonite, and india-rubber, and corroborates the very low value found by Prof. Stefan, of Vienna, for the conductivity of ebonite. It has also corrected some imperfections of its former tables, by showing that the values given in them have throughout been described too low, by about an eighth of their assigned values, and find that with this correction their results have been in close accordance with the measures that Sir William Thomson and other observers deduced of the conductivities of soils and rocks in places where underground thermometers have been sunk and read regularly for many years. The records of such thermometers in the grounds of the Royal Observatory at Greenwich have been preserved continuously for more than thirty years, and the last volume of "Greenwich Meteorological Reductions" contains the observations of their temperatures for twenty-seven successive years, 1847-73. This record (already used in part by Prof. Everett) might now afford a new and very valuable determination of the conductivity of sand and gravel strata, such as make up the materials of Greenwich Hill, upon which the Royal Observatory is placed.

Report of the Committee, consisting of Prof. Sir William Thomson, Prof. Clerk-Maxwell, Prof. Tait, Dr. C. W. Siemens, Mr. F. J. Bramwell, and Mr. J. T. Bottomley for commencing Secular Experiments upon the Elasticity of Wires, by J. T. Bottomley.—At the last meeting of the British Association, the arrangements for suspending wires for secular experiments in the tube which has been erected in the tower of the Glasgow University Buildings, and for observing these wires, were described and reported as complete. Some improvements have since been found necessary; but, so far as these are concerned, there is not much to add to the report then given.

The long iron tube has been closed at the top and bottom so as to keep out currents of air and dust, and the joints of the tube have been carefully caulked.

Some improvements in the cathetometer used for observing the marks on the wires were also found to be required, but the instrument is now satisfactory.

Six wires have now been suspended in the tube; their stretching weights have been attached to them, and they have been carefully marked and measured. These wires are suspended in pairs—two of gold, two of platinum, and two of palladium. One of each of the pairs is loaded with a weight equal to one-twentieth of its breaking weight, and the other of each pair with a weight equal to one-half of its breaking weight. The points of suspension for each pair are very close together, so that any yielding of the place of support affects both wires equally.

Each wire is marked with paint marks, and there are other marks on the wires and on the weights attached to them where positions have been determined. These marks are described in a laboratory book which is at present kept in the room of the professor of natural philosophy in the University of Glasgow. The measurements that have been made, and the experiments that have been undertaken in connection with the work assigned to the Committee, are all being entered in this book. This, however, can only be regarded as a temporary mode of keeping these records.

It is intended that the record in this book shall contain—

1. Description of the tube and arrangements for suspending the wires, and for suspending additional wires at future times, and description of the mode of attachment of the stretching weights.

2. Description of the cathetometer and method of measuring the changes, should there be any, in the lengths of the wires.

3. Description of the wires themselves, and record of experiments that have already been made on them as to breaking weight and Young's modulus of elasticity.

4. Description of the marks put on the wires, and record of the measurements that have been made as to the lengths of the wires and as to the relative positions of the marks at the time of suspending the wires.

The stretching weight and the clamps attached to the wires are engraved each with the amount of its weight in grammes. The measurements are all made in grammes and centimetres.

It seems desirable, considering the nature of the experiments that are just now commencing, that information regarding them should be preserved to the British Association in some appropriate way; and that provision should be made for recording every change that may take place, and for communicating from time to time to the Association such information as may be obtained.

In the report presented to the Association by this Committee last year, it was mentioned that experiments had been commenced in the laboratory of the University of Glasgow in connection with the present investigation on the effects of stress maintained for a considerable time in altering the elastic properties of various wires. These experiments are still being carried on, and results of interest and importance have been already arrived at.

The most important of these experiments form a series that have been made on the elastic properties of very soft iron wire. The wire used was drawn for the purpose, and is extremely soft and very uniform. It is about No. 20 B.W.G., and its breaking weight, tested in the ordinary way, is about 45 lbs. This wire has been hung up in lengths of about 20 feet, and broken by weights applied, the breaking being performed more or less slowly.

In the first place, some experiments have been tried as to the smallest weight which, applied very cautiously and with precautions against letting the weight run down with sensible velocity, will break the wire. These experiments have not yet been very satisfactorily carried out, but it is intended to complete them.

The other experiments have been carried out in the following way:—It was found that a weight of 28 lbs. does not give permanent elongation to the wire taken as it was supplied by the wire drawer. Each length of the wire, therefore, as soon as it was hung up for experiment, was weighted with 28 lbs., and this weight was left hanging on the wire for 24 hours. Weights were then added till the wire broke, measurements as to elongation being taken at the same time. A large number of wires were broken with equal additions of weight, a pound at a time, at intervals of from three to five minutes—care being taken in all cases, however, not to add fresh weight if the wire could be seen to be running down under the effect of the weight last added. Some were broken with weights added at the rate of one pound per day, some with three-quarters of a pound per day, and some with half a pound per day. One experiment was commenced in which it was intended to break the wire at a very much slower rate than any of these. It was carried on for some months, but the wire unfortunately rusted, and broke at a place which was seen to be very much eaten away by rust, and with a very low breaking weight. A fresh wire has been suspended, and is now being tested. It has been painted with oil, and has now been under experiment for several months.

The following tables will show the general results of these experiments. It will be seen, in the first place, that the prolonged application of stress has a very remarkable effect in increasing the strength of soft iron wire. Comparing the breaking weights for the wire quickly broken with those for the same wire slowly broken, it will be seen that in the latter case the strength of the wire is from two to ten per cent. higher than in the former, and is on the average about five or six per cent. higher. The result as to elongation is even more remarkable, and was certainly more unexpected. It will be seen from the tables that, in the case of the wire quickly drawn out, the elongation is on the average more than three times as great as in the case of the wire drawn out slowly. There are two wires for which the breaking weights and elongations are given in the tables, both of them "bright" wires, which showed this difference very remarkably. They broke without showing any special peculiarity as to breaking weight, and without known difference as to treatment, except in the time during which the application of the breaking weight was made. One of them broke with 44 lbs., the experiment lasting one hour and a half; the other with 47 lbs., the time occupied in applying the weight being thirty-nine days. The former was drawn out by 28·5 per cent. on its original length, the latter by only 4·79 per cent.

Tables showing the Breaking of Soft Iron Wires at Different Speeds

I.—Wire Quickly Broken

Rate of adding weight.	Breaking weight in pounds.	Per cent. of elongation on original length.
[1] Dark Wire		
½ lb. per minute	45	25·4
1 ,, 5 minutes	45¼	25·9
,, ,, 5 ,, ...	45¼	24·9
,, ,, 4 ,, ...	44¼	24·58
,, ,, 3 ,, ...	44¼	24·88
,, ,, 3 ,, ...	45¼	29·58
,, ,, 5 ,, ...	44¼	27·78
[1] Bright Wire		
1 lb. per 5 minutes	44¼	28·5
,, 5 ,, ...	44¼	27·0
,, 4 ,, ...	44¼	27·1

[1] The wire used was all of the same quality and gauge, but the "dark" and "bright" wire had gone through slightly different processes for the purpose of annealing.

II.—Wire Slowly Broken

Weight added and No. of experiment.	Breaking weight in pounds.	Per cent. of elongation on original length.
1 lb. per day. I.	48	7·58
,, II.	46	8·13
,, III.	47	7·05
,, IV.	47	6·51
,, V.	47	8·62
,, VI.	47	5·17
,, VII.	46	5·50
,, VIII.	47	6·92 Bright wire.
¾ lb. per day. I.	49	8·50
,, II.	48¼	8·81
,, III.	Broken by accident.	
,, IV.	46	7·55
,, V.	46	6·41
,, VI.	45½	6·62
½ lb. per day. I.	48	8·26
,, II.	50	8·42
,, III.	49	7·18
,, IV.	47	4·79 } Bright wires.
,, V.	46½	6·00 }

It was found during the breaking of these wires that the wire becomes alternately more yielding and less yielding to stress applied. Thus, from weights applied gradually between 28 lbs. and 31 or 32 lbs., there is very little yielding and very little elongation of the wire. For equal additions of weight between 33 lbs. and about 37 lbs. the elongation is very great. After 37 lbs. have been put on, the wire seems to get stiff again, till a weight of about 40 lbs. has been applied. Then there is rapid running down till 45 lbs. has been reached. The wire then becomes stiff again, and often remains so till it breaks.

It is evident that this subject requires careful investigation.

Report of the Committee for effecting the Determination of the Mechanical Equivalent of Heat.—The Committee had little to report this year, the work in progress being the protracted one of supplying a means of correcting errors in the determination of the temperature arising from the temporary changes of the fixed points of thermometers constructed of glass. They had learned with pleasure that an extensive series of experiments had recently been made by Prof. H. A. Rowland, of Baltimore, who, being unaware of what had been done by the Committee, had arrived at an equivalent almost identical with that determined by Mr. Joule.

Report of the Committee appointed for the Purpose of endeavouring to procure Reports on the Progress of the Chief Branches of Mathematics and Physics.—Owing to unforeseen circumstances no meeting of this Committee has taken place during the past year. It seems desirable, nevertheless, in order that the question of the reappointment of the Committee may be fully considered, and that there may be a full expression of opinions on the subject referred to it, that a statement should be made to the Section of the proceedings of the Committee, the more so since, in the hope that greater progress would have been made by this time, no report was presented at the last meeting of the Association.

The first matter discussed by the Committee was the character and general plan of the reports which they should endeavour to procure; the next was to what extent or in what manner the production of such reports could be aided by the Committee. Important contributions to the discussion of these questions are contained in written communications to the Committee from two of its members, Professors Clerk-Maxwell and Stokes. Prof. Clerk-Maxwell writes as follows:—

"Reports on special branches of science may be of several different types, corresponding to every stage of organisation, from the catalogue up to the treatise.

"When a person is engaged in scientific research, it is desirable that he should be able to ascertain, with as little labour as possible, what has been written on the subject and who are the best authorities. The ordinary method is to get hold of the most recent German paper on the subject, to look up the references there given, and by following up the trail of each to find out who are the most influential authors on the subject. German papers have the most complete references, because the machinery for docketting and arranging scientific papers is more developed in Germany than elsewhere.

"The *Fortschritte der Physik* gave an annual list of all papers, good and bad, arranged in subjects, with abstracts of the more important ones. Wiedemann's *Beiblätter* is a more select assortment, given more in full.

"I think it doubtful whether a publication of this kind, if undertaken by the British Association, would succeed. Lists of the titles of the proceedings of societies and of the contents of periodicals are given in NATURE. These are useful for strictly contemporary science, and I do not think that a more elaborate system of collection could be kept up for long.

"The intending publisher of a discovery has to examine the whole mass of science to see whether he has been anticipated, but the student wishes to read only what is worth reading. What he requires is the names of the best authors. The selection or election of these is constantly done by skimming individual authors, who indicate by the names they quote the men whose opinions have had most influence. But a report on the history and present state of a science has for its main aim to enumerate the various authors and to point out their relative weight, and this has been very well done in several British Association reports, some of which are nearly as old as the British Association.

"There are some branches of science whose position with respect to the public, or else to the educational interest, is such that treatises or text-books can be published on commercial principles, either as books to be read by the free public, or to be got up by the school public.

"There is little encouragement, however, for a scientific man to write a treatise so long as he can, with much less trouble, produce an original memoir, which will be much more readily received by a learned society than the treatise would have been by a publisher.

"The systematisation of science is therefore carried on under difficulties when left to itself; and I think that the experience of the British Association warrants the belief that its action in asking men of science to furnish reports has conferred benefits on science which would not otherwise have accrued to it.

"There are so many valuable reports in the published volumes that I shall indicate only a few, the selection being founded on the direction of my own work rather than on any less arbitrary principle.

"First, when a branch of science contains abstruse calculations as well as interesting experiments, it is desirable that those who cultivate the experimental side should be conscious that certain things have been done by the mathematicians. The matter to be reported on in this case is not voluminous, but it is hard reading, and those who are not experts require a guide.

"Thus, Prof. Challis in 1834 gave a most useful report on the mathematical investigations by Young, Laplace, Poisson, and Gauss on capillary attraction, and Prof. Stokes in 1862 reports on theories of double refraction. This report may, indeed, be accepted as an instalment of the treatises which, if the desire of the scientific world were law, Prof. Stokes would long ago have written. It is meant, no doubt, as a guide to other men's writings, but it is intelligible in itself without reference to those writings. Such a report is a full justification of the existence of the British Association, if it had done nothing else.

"Another type of report is that of Prof. Cayley on dynamics (1857 and 1862). This seems intended rather as a guide in reading the original authors than as a self-interpreting document, though, of course, besides the criticism and the methodical arrangement, there is much original light thrown on the mass of memoirs discussed in it. It will be many years before the value of this report will be superseded by treatises.

"The report of the Committee on mathematical tables deals with a subject which, though not so abstruse, is larger and dryer than any of the preceding. It is, however, a most interesting as well as valuable report, and supplies information which would never have been printed unless the British Association had asked for the report, and which never would have been obtained if the author of the report had not been available.

"There are several other reports which are not mere reports, but rather original papers preceded by a historical sketch of the subject. No special encouragement is needed to get people to write reports of this kind."

Prof. Stokes thus expresses himself on the subject:—

"It seems to me that reports on the progress of science may be of two kinds, with somewhat different objects in view; and in considering the best mode of meeting these objects, it may be well to keep the distinction in view.

"First, there is a report, the object of which is to prepare a sort of repertorium of what has been done in a particular branch of science since the date of the last report of similar character in the same branch of science.

"A report of this kind should present the reader with a brief account of the leading aim and chief results of the various memoirs which have been published within the time on the branch of science to which it relates; the writer should not be expected to criticise the memoirs, except in plain instances of errors or imperfections, but the responsibility of sifting the wheat from the chaff should in the main be left to the reader.

"Secondly, there are reports of a more comprehensive and far more critical character. These should be made at wider intervals, should take a more comprehensive view of the subject, and should be highly critical, sifting out the substantial acquisitions that had been made to the branch of science to which they refer.

"Each kind of reports are of value, though in somewhat different ways. The first aids the individual in keeping himself up to the progress of science around him—a progress in which from his position he may be expected to take part and to exercise influence. They lighten to him the labour of search, but teach him to exercise his own discrimination.

"The second should be a material aid to the student in making himself master of what was really of value, and help him to avoid wasting his time on what was of little importance, and aid him in judging of the relative importance of different lines of research.

"Reports of the first kind may be much promoted by the work of committees. The division of labour lightens the task, and the feeling of co-operation carries a man through labour which otherwise, as the man is likely to have a good deal else to do, he might hesitate to undertake.

"Reports of the second kind eminently demand the hand of a master, and the hand of a master is not always free. I doubt much if the appointment of committees would aid much in the preparation of *good* reports of this class, and unless reports are thoroughly good they are better, perhaps, not attempted. I do not see what is to be done except to work a good man *when you can get him*."

It is evident that the distinction here pointed out by Prof. Stokes has an important bearing on the question of the re-appointment of the Committee. The work required for the production of reports intended simply as systematic records "of the leading aim and chief results" of published investigations, would be merely that of careful compilation. It would not only be possible to divide work of this kind among a considerable number of contributors, but to get it done at all such division of labour would be necessary, and accordingly reports of this class could only be furnished by committees. On the other hand, a report which is of the nature of a critical survey of the condition of knowledge in any branch of science, and is intended to indicate the relative value of different investigations, requires to possess a unity of plan and thought which can only result from its being the work of an individual author possessing a complete mastery of his subject. In such a case the function of the committee would be confined to the suggestion of the subject and to requesting some qualified person to report upon it—a function which hitherto has been discharged by the Sectional Committees of the Association.

Report of the Committee, consisting of Prof. Sylvester and Prof. Cayley, appointed for the Purpose of calculating Tables of the Fundamental Invariants of Algebraic Forms.—The valuable services of Mr. F. Franklin, of the Johns Hopkins University, has computed, under Prof. Sylvester's inspection, the *ground forms* (otherwise called the fundamental invariants and covariants) of binary quantics of the 7th, 8th, and 10th orders respectively, thus rendering the list of tables of such forms complete for quantics of all orders up to the 10th inclusive.

The tables of the *Grundformen* of the seventhic and tenthic are published in the *Comptes Rendus de l'Institut*, 1878, 1879; the table of the *Grundformen* of the ninethic in the *American Journal of Mathematics*, March, 1879, and in a future number of that journal will shortly also appear the intermediary tables of the Generating Functions from which such *Grundformen* are deduced.

These tables, in addition to those previously constructed, will, it is believed, form a valuable, and (for the present) a sufficient, basis for the prosecution of this kind of research in what regards the theory of single binary quantics, leaving a wide field still open for computations of a similar nature connected with systems of binary quantics and binary and semi-binary quantics, single or in systems.

Report of the Committee on Atmospheric Electricity in Madeira, by Dr. M. Grabham.—Daily observations in Madeira extremely monotonous, showing very little variation, though suggesting the importance of a station so uniform in weather for the careful observance of diurnal and seasonal changes. The writer, giving himself to the observation of the regular winds and breezes, traces the steady rise of electricity in the early morning to a maximum at 11·30 A.M., which declines after much steadiness for two hours, at first suddenly and then very gradually towards night.

Remarkable fluctuations are noticed during the formation of the maximum which the writer ascribes to masses of cloud on moist air. A description follows of the daily formation of a thin stratum of cloud during fine calm weather which varies slightly in altitude in accordance with temperature and barometric pressure. The electricity below this cloud is always positive and moderately strong. In the cloud itself it is more feeble but of the same sign. Above the cloud at the station where the observation was taken it was very feeble and irregular but always positive. In warmer weather the vapour does not condense into cloud but appears as a blue transparent haze from above, and presents the same electrical indications.

The writer states that all observations in his own garden were vitiated or mitigated by the presence of lofty trees.

The highest potential was observed upon a rock ninety feet high, a few metres from the shore in the Bay of Funchal.

The thinness of the currents of air constituting sea breezes was demonstrated by flying a kite vertically beyond into the true wind blowing in a contrary direction. Abortive attempts were made to bring down the upper electricity through the lower currents. The electricity of the general north-east wind which is identical with the trade wind was found on the heights at the east end to be uniformly moderate and positive.

At the approach of rain-clouds at the termination of a period of fine weather the atmosphere invariably gives increased readings and no negative observations were recorded.

A short description follows of the L'este, a kind of sirocco to which Madeira is occasionally subject and which blows with great force on certain limited mountain districts bringing sand, birds, and other evidence of a distant origin. This wind is extremely dry, in a temperature of 85° the dew points being depressed below freezing. Electrically this wind in its integrity gives no indication of any change whatever except by faint fluctuations about the earth reading.

The writer also notices a very highly electrical condition during the prevalence of L'este wind, of certain clouds which lie quietly among the mountains, though tossed and tumbled on their upper surfaces; he hopes to be able to connect their forms and immobility with their electrical change.

Report of the Committee on Mathematical Tables, by James Glaisher.—In the course of the year the factor table for the fourth million has been printed and stereotyped, and is nearly ready for publication. The manuscript of the factor table for the fifth million is complete. The table for the sixth million is complete as far as the factors entered by the sieves are concerned, but the factors obtained by the multiple method still need entering, and the whole has to be verified. The mode of calculation was described in last year's report, and a more complete account will appear in the introduction to the fourth million. The present report contains the result of the enumeration of the primes in the fourth million, and a list of long sequences of composite numbers occurring in it. The report also contains a table of the first seven Legendrian coefficients, viz., $P^n(x)$ for $n = 1$ to $n = 7$, where

$$P^1(x) = x,\ P^2(x) = \tfrac{1}{2}(3x^2 - 1),\ P^3(x) = \tfrac{1}{2}(5x^3 - 3x),$$
$$P^4(x) = \tfrac{1}{8}(35x^4 - 30x^2 + 3),\ \&c.,$$

each for a hundred values of the argument.

Report of the Committee on Luminous Meteors, by James Glaisher.—After recording the regret the Committee felt at the loss of two of the most active workers—Mr. Greg by his retirement, and Mr. Brooke by death—the report stated that the very unfavourable weather had generally caused only very meagre views of the annual star showers of October, December, January, and April to be seen. The major showers of August had also been hidden from view, owing to the unfavourable weather. The report then dealt in detail with the accounts of conspicuous detonating fire-balls that had occurred in the United States on August 11 and December 18, 1878, and on January 27, 1879; in Bohemia and Saxony on January 12, 1879, and in England on February 22 and 24, 1879, the real paths of all of which had, to a greater or less degree of certainty and closeness, been approximately ascertained. The rest of the report was devoted to a description of the past year's aërolites. The expected return of Biela's comet to its perihelion in the present year, leading a shower of shooting stars to be looked for with much confidence among astronomers on November 27 next, is to be taken advantage of to report next year on meteor showers. As in former years the Committee were under great obligations to Prof. A. S. Herschel for the labour he had bestowed on the report.

Report of the Committee for Calculating Tables of Sun-heat Coefficients, by Rev. Dr. Haughton.—A table showing the total heat received by various latitudes from the sun in the course of a year had been formed; and the work would be completed by next year. The results already obtained have appeared in the *Proceedings* of the Royal Dublin Society.

Report of the Committee consisting of the Rev. H. T. Barnes Lawrence, Mr. Spence Bate, Mr. H. E. Dresser (Secretary), Mr. J. E. Harting, Dr. Gwyn Jeffreys, Mr. J. G. Shaw Lefevre, M.P., Prof. Newton, and the Rev. Canon Tristram, appointed by the Council, for the purpose of Inquiring into the Possibility of Establishing a Close Time for the Protection of Indigenous Animals.—Your Committee has gratefully to acknowledge the resolution of the Council of the Association, whereby your Committee has been not only reappointed but also instructed to report to the Council in case of any action being required. Your Committee begs leave to state that no such emergency as was provided for by this instruction has arisen since the presentation of its last report. Notwithstanding complaints that are occasionally heard, your Committee believes that public opinion continues strongly in favour of the close time principle, as applied to indigenous animals; and on the part of Her Majesty's Government no steps have been taken to carry out the recommendations of the Scottish Herring Fishery Commissioners, upon which your Committee deemed it its duty to animadvert last year. The Bird Preservation Acts, though doubtless evaded in some places, in general appear to work well, and to be enforced without difficulty when occasion requires. Having regard to future contingencies, your Committee ventures to solicit its reappointment with the instructions as to reporting to the Council in case of emergency.

Report of the Committee consisting of Mr. Sclater, Dr. G. Hartlaub, Sir Joseph Hooker, Capt. F. M. Hunter, and Prof. Flower, appointed to take Steps for the Investigation of the Natural History of Socotra.—The Committee have not held any formal meetings, but have been in frequent communication with each other on the subject.

The best time for the exploration of Socotra being from November to March, the Committee were not able to make the necessary arrangements last autumn. Next winter, however, they believe that Col. H. H. Godwin-Austen, than whom no more competent naturalist could be found, will be able to undertake an expedition to Socotra, and to make a thorough investigation of its natural history. Col. Godwin-Austen has applied to the Surveyor-General of India for the use of some of the assistants on his staff, and proposes to make a complete topographical survey of the island during the expedition.

It is estimated that the total cost of the expedition will be about 300*l*. Of this 100*l*. granted by the Association last year, has been received by the Committee and deposited in the London and County Bank at interest. The sum of 175*l*., having been devoted to this same purpose out of the Government Fund of 4,000*l*. administered by the Royal Society, has been paid to Col. Godwin-Austen, and has been added to the account at the London and County Bank.

There remains, therefore, only 25*l*. requisite to complete the sum of 300*l*., which the Committee consider will be required for the expedition.

The Committee request that the Committee for the investigation of the Natural History of Socotra may be re-appointed with the additional name of Col. H. H. Godwin-Austen, and that the balance of 25*l*. necessary to complete the estimate of expenditure may be placed at their disposal.

Report of the Committee on an Instrument for Detecting Fire-damp in Mines, by Prof. G. Forbes.—From the rough model shown last year the Committee had constructed two new instruments, which appeared to them to answer the purpose of measuring the quantity of fire-damp in a coal mine. The one was of a large size, and was worked by an electric battery. The other was small, portable, easily worked, and it answered all the purposes for which it was required. Both instruments were founded upon the facts that sound travels quicker in light gases than in dense ones, and that air which is contaminated with fire-damp is lighter than pure air. The velocity of sound in different qualities of air was compared by noting the lengths which must be given to a brass tube to cause it to resound to a tuning-fork. The accuracy of the instrument was such that the percentage of fire-damp could be determined with an error of considerably less than 1 per cent. On Monday the Committee were enabled to descend the Wharncliffe Silkstone Colliery, in the neighbourhood of Sheffield, by the kindness of the manager, Mr. George Walker, who accompanied them with a number of gentlemen interested in the experiments. This pit was at a depth of 200 yards. Mr. Walker had kindly arranged to stop the ventilation and the pit at the end of the workings. After proceeding for a mile through the galleries they reached this spot, where they hoped to find a large amount of fire-damp. But only a slight quantity was to be found, the Davy lamp generally showing but a feeble blue cap, and the Forbes indicator registering only small percentages. Disappointed here, they were taken by Mr. Walker to another working, where it was thought possible there might be some gas. In a crevice in the roof a flow of gas was found, forming a stratum of light gas. The instrument indicated quantities which gradually increased, as the tube got filled with the air in the crevice, from 14 to 28 per cent. But the small quantity of gas rendered the experiment unsatisfactory, and the Committee were then taken to a disused part of the mine, where it was known there was a blower. Gas in sufficient quantities was found, and the instrument registered gas with more readiness than the Davy lamp. But the greatest quantity registered was 6 per cent., or twelve times the smallest quantity which the indicator detects. There was in the present form of the instrument a difficulty in filling the tube with the air of the place under examination, and the Committee considered that it would be well to alter the instrument so as to obviate the difficulty. From the experiments they could assert that this instrument was capable of detecting and measuring fire-damp even in small quantities.

SECTION A—Mathematical and Physical

On Lightning Protectors for Telegraphic Apparatus, by W. H. Preece.—For many years it was not the practice in England to protect telegraphic apparatus from the injurious effects of atmospheric electricity because the damage done was so insignificant, and because the remedy was found to be worse than the disease. But as telegraph systems increased, as the country became enveloped in one vast network of wires, it was found that the damage done became considerable, until, in fact, about 10 per cent. of the apparatus in use were in one year damaged.

Lightning protectors then became essential. Many forms were tried based on the fact that when a discharge takes place through a non-conductor such as dry air, at the moment of discharge the resistance along the line of discharge is practically nothing, and therefore all the charge is conducted away. According to Faraday, "the ultimate effect is exactly as if a metallic wire had been put into the place of the discharging particles" ("Researches," series xii.). Most of those tried failed.

The survival of the fittest has been exemplified in the "plate" protector. In this form—one of the earliest introduced—one thick plate of brass is in connection with the earth, and another similar plate in connection with the line, is placed above it, but separated from it by paper, or by insulating washers. The lightning entering the wire bursts across the paper or air-space in preference to passing through the apparatus, and thus escapes to earth.

An important modification of this plate discharger has been made by Dr. Werner Siemens, who, by serrating, or grooving with a pointed tool the opposing faces of the two plates at right angles to each other, converted them into a conductor which was supposed to be one composed of an infinite number of opposing points. The remarkable action of points in facilitating discharge is well known, and their introduction into lightning protectors occurred very early in the annals of telegraphy by Mr. C. V. Walker, F.R.S.

Messrs. Siemens's arrangement, very pretty in theory, never carried conviction of its value to the mind of the author, because protectors so prepared never singled themselves out as evidently superior to others that were not so prepared, and while the intersection of the grooves certainly formed mathematical points, they did not form physical or mechanical points, and it is upon the action of this latter kind of points that such remarkable electrical effects are produced.

Dr. Warren de la Rue having very kindly placed his well-known battery of 11,000 cells at the disposal of the writer, he prepared four plate-protectors identical in dimensions, excepting that two were serrated, and two were not. The two plates were separated from each other by narrow ebonite washers ·01 inch thick. The upper plate was placed in connection with the positive pole, and the lower plate with the negative pole. The number of cells were increased until a continuous current of electricity flowed.

1.—*Plain Plates*

Number of Cells.		Effects produced.
1,000	...	Slight sparks commencing on completing circuit.
1,080	...	Sparks evident.
1,200	...	Sparks frequent and abundant.
1,500	...	Continuous arc.

2.—*Serrated Plates*

Number of Cells.		Effect produced.
1,000	...	Sparks just commencing on making contact.
1,080	...	Sparks evident.
1,200	...	Sparks frequent.
1,500	...	Continuous arc, but fitful.

2,000 cells in each produced a continuous stream of electricity. The effect with 1,500 cells was decidedly more marked with the plain plates than with those serrated. The experiments were extremely pretty, and very decided in their character. Hence it appears that grooving is not only of no use, but that it rather deteriorates the value of the protector.

These experiments confirm very decidedly the accuracy of the figures obtained by Dr. Warren de la Rue and Mr. Müller on the striking distance between two flat disks given by them in their paper read before the Royal Society (*Phil. Trans.*, vol. 169), where it was shown that 1,200 cells struck across ·012 inch. Here 1,000 struck across ·01 inch, which agrees perfectly with the curve produced by those observers.

It is the practice in the Post Office telegraph department to keep these plates apart by thin paraffined paper ·002 inch thick, so that the air surface is really much thinner than that experimented upon, and the striking difference of potential only 250 volts.

Messrs. De la Rue and Müller have shown that for points and various kinds of surfaces opposed to each other, plane surfaces act the best for potentials less than 1,500 volts, and that points are only efficient for high potentials. Now as it is doubtful whether atmospheric electricity causes much higher potential than 1,000 volts, it is clear than plane surfaces are the most effective for protecting apparatus. It is quite certain that such plates, plain and smooth, separated by an air space ·002 inch thick, will form very efficient lightning protectors.

The author is very much indebted to Dr. Warren De la Rue for the performance of the experiments in his laboratory.

Experiments made to determine the Friction of Water upon Water at Low Velocities, by Rev. S. Haughton, M.D., D.C.L.—The author's intention, in commencing the experiments, was to ascertain the co-efficient of tidal friction, and also to ascertain the elevation of water at the equator or pole, necessary to cause a current; and both these results he hopes to secure with some approach to accuracy.

The experiments were conducted by means of a spherical ball of granite, unpolished, which was suspended by a pianoforte wire, and allowed to hang freely; from the brass collar by which the ball was suspended an index projected on each side, the pointed ends of the indices traversing a graduated horizontal circle, whose centre corresponded with the line of suspension. The suspended ball was immersed in water contained in an iron tube.

On the Tension of Vapours near Curved Surfaces of their Liquids, by G. F. Fitzgerald.—The paper is intended to give a physical explanation of the fact that the tension of a vapour in contact with the surface of its liquid when that surface is convex or concave is greater or less respectively than when flat. It rests upon the assumption that evaporation is not purely superficial but that molecules are emitted from a certain depth beneath the surface of a liquid. From this it follows that the chances of escape of a molecule from a given depth below a convex surface are greater, and from a concave less than from a flat one. Taking the depth from which emission takes place as very small compared with the radii of curvature of the surface, the author has deduced the same formula for the increase or diminution of tension as Sir W. Thomson deduced from capillary phenomena.

Etherspheres as a Vera Causa of Natural Philosophy, by Rev. S. Earnshaw, M.A.—The author, assuming an admitted parallelism between the phenomena of light and heat, proceeds by means of three hitherto overlooked propositions in natural philosophy to establish the universal existence of what he has denominated *etherspheres*, the third of his propositions being—"Every atom of matter in the universe is surrounded by an ethersphere of its own." The following is the system of nature which he finds sufficient for his purpose:—

1. In nature there are two distinct substances, matter and ether, neither of which has any power to attract or repel the other.

2. Matter consists of atoms which attract each other with forces varying according to the Newtonian law $(\text{distance})^{-2}$.

3. The atoms of bodies of the same kind are alike in all respects; atoms of bodies of different kinds differ from each other in size, and possibly also in other respects, such as shape, &c.

4. Atoms, whether of matter or of ether, are incapable of experiencing any change of figure or dimensions; and they are all assumed to be of such geometrical forms as cannot fill space.

5. From the phenomena of light it has been inferred that atoms of ether repel each other with a force varying as $(\text{distance})^{-4}$.

6. Every atom of matter is impervious to ether, and acts on ether in no other way than by pressure of contact.

7. A portion of space filled with matter is necessarily void of ether; and all space void of matter is pervaded by ether.

8. The enormous velocity of light in free space has led to the opinion that very great must be the repulsive power of ether on ether; and it seems to follow from this that an ether atom will experience great difficulty in moving from one part of the ethereal medium to another. Except as waves and currents, ether motion will be under great restraints, and especially shall we see this when we also remember the high power (viz., the fourth) of its inverse law of force.

9. In free space light is believed to be transmitted with the same velocity in every direction, and from this we infer that the atoms of ether are all spherical in form.

The following is the author's definition of an ethersphere:—

All space not filled by matter is pervaded by ether, so that every atom of matter is surrounded by ether, but this is not what is included in the word "ethersphere." The author shows that if any portion of space be rendered void of ether from any cause whatever, that space has become void of the repulsive forces which were centred within it, and that, consequently, when these forces are taken away the medium outside the space will draw closer towards that space; and if the space be occupied by an atom of matter, the density of the surrounding ether will be greater than before, and the ether, being in contact with the atom at its surface, will press upon it. This *excess* of ether about the vacant space above its original quantity constitutes the ethersphere; and though this gathering together of ether about the space now occupied by the atom is a consequence of the presence of the atom, it is in no way owing to its action on the ethereal medium.

The author then argues that if every material atom, so must every compound system of atoms, *i.e.*, every material body, whether gaseous, liquid, or solid, have an ethersphere, which not only surrounds the whole body, but also penetrates the interstitial spaces of the body which lie between its atoms.

By means of these etherspheres the author believes the phenomena of heat may be satisfactorily accounted for, on the supposition that the ethereal medium is the medium of heat as well as of light. They are shown in the original memoir itself to have a remarkable bearing also on the phenomena of magnetism, electricity, galvanism, and the various sciences connected with the agency of imponderables. He therefore concludes that etherspheres constitute a *vera causa* the existence of which in nature is as certain as is that of the ethereal medium itself, about which no philosopher expresses doubt in the present day.

On the Fundamental Principles of the Algebra of Logic, by Alexander Macfarlane, M.A., D.Sc.—In a work recently published, entitled "The Algebra of Logic," the author has investigated anew the foundations of that branch of mathematical analysis which was originated by Boole in his celebrated treatise on "The Laws of Thought." In making this inquiry the author has studied the contributions to the subject made by Harley, Venn, Jevons, and others.

The difficulty and apparent irrationality of Boole's calculus is due to the fact that it is founded on the old and inadequate theory of the operation of the mind in reasoning about quality. That theory supposes that the mind, in forming a compound conception out of two simple conceptions, necessarily considers the second of these as limited by, and in a measure dependent upon, the first; in the theory which the author advances it is maintained that the mind may, on the other hand, form compound conceptions in which the second element is entirely dependent on the first; and, on the other hand, compound conceptions, in which the two elements are mutually independent.

The author considers that the fundamental notion in this branch of analysis is that of a collection of homogeneous objects having differentiating characters. The collection of objects, so far forth as they are homogeneous, may be denoted by u (as they form the universe considered in the particular investigation); a differentiating character may be denoted by a small letter, as x. The symbol x applies to, and is entirely dependent upon, u. The arithmetical value of u is the number of the objects considered, and may be singular, plural, or infinitely great. The arithmetical value of x is the ratio of the number of the objects which have the character x to the whole number of objects considered. The author then explains the meaning of the letters and symbols in this system of logic.

On Synchronism of Mean Temperature and Rainfall in the Climate of London, by H. Courtenay Fox, M.R.C.S.—The object of the paper is by the examination of a long series of facts to ascertain whether there be any law which regulates the *occurrence at the same time* of extremes of temperature and rainfall, so far as we can ascertain it in the English climate.

The facts used are the rainfall and mean temperature as for the Royal Observatory in each month and season for 66·67 years. The mean temperature from 1813 to 1840 is that computed by Mr. James Glaisher, F.R.S., (*vide Philosophical Transactions*, 1850, part 7); and from 1841 to the present time, it is from direct observation. The rainfall from 1830 to 1840 is derived from sundry observations about London collated by Mr. George Dines, and from 1841 to the present time it also is from direct observation at the Greenwich Observatory.

The author has constructed tables *for each month*, in which the sixty-seven (or sixty-six) years are arranged in the order of the mean temperature of that month, beginning with the coldest and ending with the warmest, and also arranged in like manner in the order of their amount of rain. The sixty-seven years are then divided, as nearly as can be, into five equal sections, of which the middle section is termed average years; the division on each side of the average are termed cold and warm, dry and rainy, respectively; while the extreme sections are qualified by the word *very*, being called very cold, very warm, very dry, and very rainy, respectively. We have thus a pretty fair division of the series of years in both these characters. What has been done for each month has been also done on exactly similar principles for each season and for the whole year. The results found were:—

1. In the winter months, cold tends to be synchronous with dryness, warmth with large rainfall.

2. In the summer months, cold tends to be accompanied by much rain, warmth by dryness.

3. Rainy years tend to be either very cold or very warm, whilst years of drought tend to assume an average temperature.

Experiments on the Influence of the Angle of the Lip of Rain Gauges on the Quantity of Water Collected, by Baldwin Latham, C.E., M. Inst. C.E., F.G.S., F.M.S.—The author having observed that, in the ordinary pattern of the Glaisher gauge, in high winds the rain was often driven up the sloping lip and into the gauge, thought that if the rim of the gauge were made very acute, having a sharp knife edge and equal angles both inside and outside the gauge, any rain which might strike upon the outer angle on one side of the gauge might be thrown into the gauge. Rain striking upon the inner and opposite side of the gauge would be thrown out, and so an equilibrium rim would be constructed, as the gain on one side would be balanced by the loss on the other side.

With this view, the author had an 8-inch gauge made and tested alongside of an 8-inch Glaisher gauge. The sloping lip of the Glaisher gauge had an angle of 45° from the perpendicular, and the rim of the equilibrium gauge was ·8 in. deep, ·18 in. in thickness, sloping off on both sides at an angle of 3° from the perpendicular. Both gauges were fixed at Croydon, 4 feet above the ground, and 259 feet above Ordnance datum. These gauges had been working side by side for 551 days, from January 5, 1878, to July 5, 1879, during which period rain or snow has fallen upon 306 occasions. Upon 43 occasions it was found that the rain collected in the Glaisher gauge exceeded, by a small amount, the rain in the equilibrium rim-gauge, and on two occasions the quantity in the new gauge exceeded that in the Glaisher gauge. Upon 261 occasions the rain in both gauges was absolutely equal. On all occasions, it should be observed, the rain from both gauges was invariably measured in the same graduated measuring glass. On the 45 occasions when the Glaisher gauge collected most rain, the wind without exception was high. On the two occasions when the equilibrium rim-gauge collected more rain than the Glaisher gauge, it was probably due to dew, the equilibrium gauge presenting a larger surface for condensation than the other gauge. As the Glaisher gauge was not calculated to contain snow, all falls of snow are recorded in the equilibrium rim-gauge, which is constructed to hold about one foot in depth of snow.

The total quantity of rain collected in the Glaisher gauge during the period of observation, plus the snow as caught in the equilibrium rim-gauge, was 46·68 in., and the quantity collected in the equilibrium rim-gauge was 46·45 in., showing a difference of but half per cent. In all probability, however, the small excess measured by the Glaisher gauge would tend to compensate for the losses by evaporation in periods of small rainfall and at other times, and therefore, as a measuring gauge, the Glaisher pattern of gange, when tested by a gauge of the description mentioned, gives results in practice which may be taken as correct.

Summary of Results

Date.	Total number of days' experiments.	Number of days when rain fell.	Amount of rain collected by Glaisher gauge.	Amount of rain collected by equilibrium rim-gauge.	Times when Glaisher gauge in excess of equilibrium rim-gauge.	Times when equilibrium rim-gauge in excess of Glaisher gauge.
			inches.	inches.		
1878.						
January ...	31	17	1·145	1·115	6	—
February ...	28	15	1·440	1·430	2	—
March	31	10	1·300	1·295	1	—
April	30	17	3·940	3·940	0	—
May	31	22	3·480	3·460	4	—
June	30	13	3·205	3·190	1	—
July	31	11	·595	·600	0	1
August ...	31	20	5·725	5·690	7	1
September ...	30	11	1·015	1·010	1	—
October ...	31	18	2·140	2·135	1	—
November ...	30	22	3·775	3·735	8	—
December ...	31	20	1·460	1·455	1	—
1879.						
January ...	31	13	2·610	2·610	0	—
February ...	28	22	3·380	3·360	4	—
March	31	13	·540	·540	0	—
April	30	19	2·535	2·515	4	—
May	31	18	3·600	3·595	1	—
June	30	20	3·690	3·680	2	—
July	5	5	1·105	1·095	2	—
Totals ...	551	306	46·680	46·450	45	2

On the Retardation of Phase of Vibrations transmitted by the Telephone, by Prof. S. P. Thompson.—It was predicted from theoretical considerations by Dubois-Reymond that a difference of phase, amounting to a quarter of a complete vibration, would be found to exist between the diaphragms of two associated Bell telephones, the receiving telephone being a quarter of a vibration behind the transmitter. A more complete theory, worked out independently by Helmholtz and Weber, gave a somewhat contradictory result, and required only a small difference of phase. Recently König in a series of delicate experiments, effected an optical comparison by the method of lissajous of the vibrations of a pair of telephones, replacing the vibrating discs by tuning-forks armed with mirrors. The experiment is a delicate one, and is performed under condition not free from objection. The author has proposed the following method of observing. A pair of Bell telephones are suspended by wires of about a metre in length, so as to oscillate as pendulums, to frames so disposed as to avoid the possibility of any mechanical transmission of the vibrations. Below the point of rest of each telephone, and at some little distance from it in the plane of its swinging, is placed a steel magnet. After the lengths of the wires have been so adjusted that the telephones will swing in identical periods, one telephone is set swinging. As it alternately approaches and recedes from the magnet, the induced currents traversing the second telephone set it swinging. In every case the difference of phase observed amounted to one quarter.

In the case of those telephones which transmit vibrations by varying the resistance of the circuit, instead of varying the electromotive force, there is no such retardation of phase produced in the ordinary electromagnetic receiver. If, however, the current so transmitted is first passed through an induction coil, a retardation of phase of one quarter is produced, and in the case of several successive inductions the retardation amounts to an additional quarter for every additional induction. This remark applies only to vibrations of harmonic and quasi-harmonic type. Vowel sounds, which consist of compound harmonic vibrations, are unchanged to the perception of the single ear, which is unable to distinguish differences of phase, or between compound sounds which differ from one another only in the difference of phase of their components. The vibrations of consonantal sounds, on the contrary, depart more and more widely from their original type at each successive induction.

In the case of Edison's motographic or electro-chemical receiver, the velocities, not the displacement of the disc, are proportional to the strength of the currents received. Hence vibrations already retarded one quarter in transmission, as is the case with those of the carbon transmitter in conjunction with its induction coil, always used with this instrument, are restored to their primitive phase. The vibrations of this receiver therefore agree in type, not with the vibrations of the induction current (which correspond to the derived function of those of the original vibration), but with those corresponding to the function of which the vibrations of the induction current are the derivate; that is to say, they agree in type with the primitive vibrations of whatever form. Hence in the receiving telephone of Edison consonantal sounds which depart widely from the purely harmonic type are better rendered than in a telephone which like that of Bell both retards the vibrations in phase and alters them in type.

On some New Instruments recently constructed for the Continuation of Researches on Specific Inductive Capacity, by J. E. H. Gordon, B.A.—Mr. Gordon exhibited and explained the following new instruments which he has arranged during the last year:—

1. A miniature five-plate induction-balance, similar in principle to the large balance exhibited at the Dublin meeting, but intended for the examination of crystals and other precious substances which cannot be obtained in sufficiently large quantities for the large balance.

The large balance requires the dielectric plates to be 7 inches square and $\frac{1}{2}$ to $\frac{3}{4}$ inch thick. For the small balance it is sufficient to make them 2 inches square and $\frac{1}{8}$ inch thick.

2. A gauge for measuring the thickness of the dielectric plates to $\frac{1}{10000}$ inch.

3. A new form of quadrant electrometer for use with the small induction balance.

The capacity of the smaller plates of the little induction balance is so minute that when they are attached to the quadrants of the electrometer of ordinary construction (Elliott pattern) disturbances in them produce hardly any effect on the needle, on account of the much greater capacity of the quadrants of the electrometer.

In order to construct an electrometer whose quadrants should have very small capacity, and which should yet be very sensitive, the author has arranged the quadrants as pieces of a flat disk, only 1 inch in diameter, and the needle has been bent round them so as to be acted on by both their upper and lower surfaces and their outside edge.

4. A new rapid commutator.

This was invented by Prof. Cornu, of the École Polytechnique, Paris, who had the great kindness to devise it for the author of this paper, who, when M. Cornu took up the matter, had just constructed three different instruments for the experiments for which this one is intended, all of which had proved unsuccessful.

Some preliminary experiments with M. Cornu's instrument have shown that it promises to be entirely satisfactory. It can be used with either the large or small induction balance on the one hand, and with a Holtz machine or battery of 500 or more cells on the other. It reverses the electrification of the plates of the balance eighteen times per second, and between each reversal, short circuits, and puts to earth both poles of the induction balance and both poles of the battery. By altering two screws it can be arranged to short circuit and put to earth the poles of the induction balance only, and to insulate the battery poles.

5. Driving-wheel for the Cornu commutator.

All the instruments have been constructed by Mr. Kieser, of the firm of Elliott Brothers.

SECTION C

GEOLOGY

OPENING ADDRESS BY PROF. P. MARTIN DUNCAN, F.R.S., VICE-PRESIDENT OF THE GEOLOGICAL SOCIETY, PRESIDENT OF THE SECTION

EVERYONE who is interested in the science which is especially considered in this Section of the British Association for the Advancement of Science must be impressed with the importance of the geological construction of this district in determining its physical geography, in producing the features of its landscapes, and in originating and developing many of the industries of the busy town of Sheffield.

It was inevitable that you should be addressed, at the commencement of your labours, upon the subject of the carboniferous formation, especially as the intention of this peripatetic congress is to advance science amongst those who require it. It will therefore be my privilege to bring before you some of the more important generalisations of the day, and some other considerations regarding the great formation which is so fully developed in this part of England; trusting that whilst many of you will submit to be reminded of the results of the labours of the men who have established our science and of those of yourselves, some who desire further information than they have hitherto obtained may be advanced in knowledge.

Of all geological formations, the carboniferous is the most important to mankind at the present time, and the most interesting to the student. It gives the earliest clear and definite idea of a land surface on the earth, or rather of the existence of many lands; for they are to be traced here and there from high up in Arctic latitudes to Australia, and from the West of America to Eastern Asia. It offers evidence of the existence, even in those remote days as in the much later miocene age, of astronomical conditions which do not now prevail. It yields proofs of the persistence of a vast lowland flora during extraordinary vicissitudes of the relative level of land and sea, and of the existence of a fauna remarkable for its great fish and amphibia, and whose air breathing mollusca and insecta are of surpassing interest, forshadowing as they do many recent forms. And its study indicates that the movements of the crusts of the earth, which occurred during and terminated the age, were of the grandest kind, and have been of the greatest importance to mankind, destroying, it is true, all the vestiges of a large part of a volume of the earth's history, but bringing coal within the reach of the explorer and miner.

This world-wide formation, usually very thick everywhere, has all the evidences of having lasted during a vast age, and there are present in it the relics of sea floors, of shallow seas and estuaries, of land surfaces, rivers, and marshes. The volcanic activity of the age was great, and is capable of demonstration.

So deep are some of the sediments composing the carboniferous formation in different parts of the world, that the idea of exact contemporaneity is not necessarily much modified. It was in all probability "coal time" universally, and for a long duration. But the beginning of the period was not synchronous in different parts of the earth, neither was the ending. The Devonian age lasted longer in some parts of the earth than in others; and the crust movements which so altered the physical geography of the carboniferous hills, dales, and swamps as to develop a new aspect of nature, terminated the period sooner in some quarters of the globe than in others. In such a locality, however as Eastern Hindostan, the duration of a carboniferous type into the secondary ages is apparent. Hence, in spite of a recognised general contemporaneity, it must be credited that carboniferous, Devonian, Permian, and later deposits were accumulated early and late during the lapse of one great age in distant parts of the globe.

The duration of the carboniferous age in the broadest sense, may be attempted, but with no great success, to be estimated by the time which must have elapsed during the world-wide dispersion of identical species; and its biological relation to the preceding and subsequent formations may be appreciated from the fact that the carboniferous flora, lasting as it did from the bottom to the top of the formation, was foreshadowed in the Devonian, and that it founded the mesozoic. Thus the Australian, Himalayan, British and North and South American marine strata of the carboniferous age contain many identical species of Brachiopoda—the variation from the English types, which were the first described, being very slight. Amongst the corals some forms are equally widely diffused. Now, according to what occurs in nature at the present time, the movements of species from one locality to another by ova, or by wafting of the young—the only method of the lateral or horizontal progress of the brachiopoda—for instance, is impeded by many physical conditions, and is constantly rendered abortive by predaceous and obstructive living forms, and by what is called the strugggle for existence. Migration, or rather the extension of the locality of the species, for the first term implies much more than was or is ever done, is so rarely possible to any great extent under the present complicated natural history and physical condition of the earth that the mind fails to grasp the time which would lapse between the commencement of the dispersive process and the establishment of identical species, even a few thousands of miles off. To bring the subject a little nearer, however, it is necessary to consider that the Arctic and Antarctic cold areas and the frigid bathymetrical ocean zones did not then exist, and that the movements of the crust, producing extension of coast lines, were exceedingly frequent during the age, and must have facilitated the dispersion of littoral and moderately deep sea species.

The dispersion of the species of the numerous cryptogamous plants was doubtless rapid in relation to that of the animals, for their spores could be wafted to a great distance by wind, and they do not appear to have had much to struggle against. With the coniferæ it was different, and the examination of the methods in which fir trees spread in favourable localities, at the present time is very suggestive of exceeding slowness of dispersion. Nevertheless, the cones of the coniferæ were carried here and there by water during the carboniferous age.

To add to the notion of the long duration of the age it must be remembered that a succession of identical floras occurred nearly on the same areas, involving repetitions of growth and of migration.

The growing of the vegetation of each swamp and lowland tract, its accumulation and covering up with sand, shales, and gravel, occupied much time, and the last process involved the destruction of considerable breadths of plant life. The formation of under-clay or warp, if the similar occurrences of the present day be taken as examples, occupied much time, and then a lapse occurred whilst the nearest flora supplied a new vegetation to the virgin soil.

In some instances the recurrence of vegetation was evidently the result of spreading from no great distance; but in others so great a depth of sediment separates the consecutive deposits of coal, and the great subsidence which took place is so evident, that the migration must have been from a considerable distance, and must have occupied commensurate time. In endeavouring to appreciate this lapse of time, it must be remembered that, even on the small surface of the United Kingdom, there was land on some parts during the whole of the carboniferous age notwithstanding the diversity of the deposits and the frequent occurrence of marine conditions.

It would appear that prior to those movements of the earth's crust which terminated the physical geography of the Devonian age, three elevated tracts of land crossed the kingdom from west to east, and that there were mountainous regions running northwards and north-westwards, including North Wales, Western Ireland, and much of the North Atlantic.

The southern high land barrier passed somewhere in the direction of the Bristol Channel, and then to the east and slightly to the south, having a somewhat definite continuation with the Ardennes. The central barrier, or high land, passed from Shropshire eastwards by Leicester, and then to the coast; and the northern was formed by hills in the present lake district, extending eastwards. On the south of the southern high land, the marine Devonian accumulated in a coral sea, and to the north of it and between it and the central barrier the old red lakes obtained their water supply and sediment from the Welsh hills of the period. North of the central barrier, interrupted lakes and land occurred, and also to the north of the northern barrier. The dry land and the barriers and hills were formed by sub-rocks of Silurian and Cambrian age.

There is no evidence to indicate that the southern barrier was of great height at the end of the Devonian period, but there is some which points out that the first physical change which initiated a new aspect of nature—the carboniferous—was a general subsidence of the region. The coral reefs sank below the bathymetrical zone of the composite forms, and the sea breached the barrier. The southern old red lake began to have its waters impregnated with salt, and its great ganoid fish were replaced by the cestraciont sharks of the age. These left their remains in the bone bed at the base of the lower limestone shales, which are the earliest of the carboniferous series there. The irruption of the sea appears to have taken place to the north of the central barrier also, and the subsidence was great there, a limestone with some sandy strata forming gradually. In the north and north-east, in the present district of the Tweed, deposits collected in shallow water, and vegetation grew which formed the coals at the base of the great Scour limestone.

On the same and on slightly higher horizons are the coals of Fallowfield, Tindal Fell, and Heskett. These are the earliest evidences of the carboniferous vegetation, and it was doubtless in full vigour whilst marine conditions existed to the south.

Probably the high lands constituting the barriers were not covered during the subsidence, which permitted the accumulation of the marine deposits of the carboniferous limestone age. For close to the coal-fields near the central barrier, and which rest on upper Silurian rock, borings here found the remains of carboniferous plants on the palæozoic rock without the intervention of any sediments.

Now the depth of the deposit of limestone about this central barrier is great, and the question arises how was it produced in the immediate proximity of land which was not covered by sea, and which does not appear to have sunk contemporaneously with the sea floor close by? Sinking along definite lines bounded by faults is the only means by which this can be explained; and this suggestion, which was a favourite topic with Phillips, is all the more probable, when it is remembered that the area of accumulation to the north of the barrier was one of vast subsidence during the consecutive ages of the grits and coal measures, whilst there was land still further north. If the stability of one and the instability of the other are not conceded, the original height of the barriers must have been stupendous and beyond example, so far as the size of their bases is concerned.

There are many examples of what I resolved to call in a presidential address before the Geological Society areas of comparative instability and which relate apparently to radial upheaval subsidence along long lines of country where movement has been rare. An instance on the grandest scale is seen in the history of the Himalayas in relation to the peninsula to their south and south-west. For whilst this last area was land during a vast age, that of the Himalayas was repeatedly a marine tract, and suffered subsidences and elevations.

Still further north and beyond the northern barrier, in the Scottish area, carboniferous plants lived a little later, and after a subsidence which permitted the lower calciferous series to accumulate. The lowest coals of the basin of the Clyde are of this age, and the accompanying clay, ironstone, and the fresh water limestones and gigantic fish of Burdie House are all indications of terrestrial conditions. All these evidences of carboniferous vegetation occur in the geological horizon of the carboniferous limestone and Yoredale series.

Never entirely free from sandy impurities the carboniferous limestones north of the central barrier gradually became covered with a thick arenaceous series containing here and there marine fossils and traces of coal plants. These are the Yoredale strata, which consist mainly of the sediments of a somewhat distant north-westerly land, the plants of which were carried to sea by rivers and deposited here and there on the sea floor. It would appear from the evidence collected by the Geological Survey that, after a very considerable thickness of these rocks had collected, either a filling up of the shallow sea or a slight upheaval of the floor occurred, for denudation of their surface happened, considerable depressions and ridges being produced on it. On those spaces and ridges, and indeed on the whole surface of the Yoredale rocks, collected strata which are popularly called the millstone grits, so well seen west of Sheffield. All the depths of this great land wreckage, consisting of silicious and felspathic sandstones and shales, accumulated on a sinking area, some near land and the rest in deeper places. And here and there coal seams are found intercalated, being evidences of the existence of contemporaneous vegetation. Some of them are workable, and others are only valuable as evidences of the existence of the vegetation of the age; many are placed on a hard silicious or ganister bed, but some have an underlying fire-clay. They are very usually covered with deposits containing goniatites and aviculopecten, which doubtless are the remains of marine organisms.

Admitting, therefore, that some of this millstone grit coal may be the result of the drifting and sinking of the vegetation from off lands rather remotely situated, it is still evident, from the existence of the under-clays elsewhere, that some of the grits, by silting up, or by slight upheaval, above sea level, formed the subsoil of swampy ground on which vegetation grew. This approach of the millstone grit sea floor to above sea level was decided enough in the region of the great coal-field around us, for a conglomeratic rock—the rough rock—occupies a somewhat definite horizon on the top of the series.

This rough rock collected in shallow water, and it is important to the geological surveyor, for it formed the base on which the coal measures, proper, rest; and it is suggestive to the physical geologist that a general and wide, but not great, upheaval took place which removed the ocean of the day further off, and which determined a total change in the direction of sediment-depositing currents.

Hitherto the greatest thickness of the sediments of the millstone grit age had been towards the north-west, and the direction of the currents had been from north-west to south-east, but subsequently, as has been suggested from very strong evidence by Sorby, the depositing currents of the next age had no very definite direction. But the carboniferous land of this part of Europe was not yet remote from the sea. Much of it was on the borders of estuaries, and the aspect of nature was probably that of wide flats of grit covered usually by terrestrial vegetation and occasionally overwhelmed by sea. In fact, both practically and theoretically there is much difficulty in separating the mill-grits from the lower coal measures. The lower measures contain some thick and widely-spread sandstones, and the important coal seams, in some instances, rest on a hard ganister bed, and in others on a fire-clay. And to add to the similarity of the deposits of the upper grits and lower coal measures, marine fossils, such as species of goniatites, aviculopecten, and posidonomya, are intercalated above the coals. But the evidences of marine invasion ceased as the deposits accumulated, and more perfect terrestrial conditions arose. The Elland flag-stones, for instance, such prominent features to the west of this town and in the neighbourhood of Halifax, are fresh-water deposits, and are undoubtedly accumulated in an under-clay indicative of terrestrial conditions.

In the region north of the northern barrier successive coal seams and impure limestones and fire-clays occurred during the age of the depositions of the English grits, and then a thick fossiliferous sandstone was followed by the upper coals of Mid-Lothian.

All the minor upheavals and upsiltings of this long age were subordinate to a progressive general subsidence, in which the central and northern barriers were slightly implicated, and this extraordinary crust movement was to continue during the accumulation of over 3,000 feet of coal measures and other deposits, all subaërial in their method of formation, or having collected in shallow water or swampy ground. These products of denudation and of organism succeeded each other time after time; great gravels, shales, and sands were intercalated, and even traces of some of the rivers of the age are to be found breaching the seams. The more the subject, commonplace as it may be thought, is considered, the more astonishing does it become, for the regularity of the subsidence and its amount must have kept pace with the thickness of the accumulating deposits. That there were many long intervals of quietude in the earth's crust may be gleaned, not only from the thickness of many coal seams, but also from the subaërial denudation which occurred. For instance, high up in the series in this district, is a mass of red sandstone which covers the denuded middle measures beneath; and this red rock of Rotherham, the result of coal measure denudation and removal, accumulated during the early days of the upper coal measures, for it is lower in the geological series than some members of the uppermost coal measures.

Before the close of the age, marine conditions occurred in the rock, and a limestone with goniatites was formed; but still coal seam formation proceeded until a totally different series of crust movements commenced in this country.

The flexures which were produced at the close of the carboniferous age had their long axes east and west; they suffered denudation and on the worn edges of their strata the "used-up carboniferous"—the lower Permian. Elsewhere, resting apparently and often really conformably on the carboniferous strata, the Permians accumulated until great north and south curvatures occurred and produced the Pennine chain.

The denudation of the anticlinal or upward curves of the north and south flexures progressed, and the coal measures, once continuous across England, were worn off along the back-bone of the country and from off the east and west ridges also. Vast as was the destruction and removal, there was still more compensation in nature, for faulting occurred on a large scale, and the measures were in many places sunken down below the level of possible subaërial denudation. It is to the pre- and post-Permian crust movements in producing basins and in uptilting the formerly horizontal seams, and to the subsequent faulting, that we owe the preservation and the possibility of reaching and working much of the coal of this country.

It appears that the position of this town refers quite as much to some remarkable faults, and the results of the post Permian uptilting, as to the presence of the river Don. Two important lines of fault run almost parallel, the one traversing the centre of Sheffield, and the other being to the north of the outcrop of the Silkstone coal. They pass in a north-easterly direction, and the country between them is much broken. Moreover, by a combination of the results of uptilt and faulting, the strike of important coal seams has been so altered that they encircle the town on the south, west, and north. The mineral products have thus been brought within the reach of those by whose industry this town has increased in size and population.

With regard to the lithology of some of the great series just mentioned, it may be suggested that the condition under which the beautiful limestones of the Avon, and the dark, shaly, muddy, calcareous deposits of the corresponding age accumulated in Scotland, were very different. The stone in the southern example is many-coloured and is nearly an organic deposit, whilst the shaly strata of the northern series have crowds of calcareous fossils in them. Remove the shaly substance, however, and consider and compare the fossils of both localities, and no satisfactory distinction can be drawn between the depths at which they may have accumulated.

Both deposits contain crinoids, polyzoa, brachiopoda, and simple and compound hydro-corals. The same occur in the limestones to the north of the central barrier, which are intermediate in the arenaceous condition between those just mentioned. It is admitted that the mineral condition of the original deposits has altered, and it is possible that much impurity may have been removed by percolating carbonated waters, from the purest of the limestones. And, indeed, unless this is credited, it is impossible to compare some of these old marine sediments with any now forming on the floor of the sea. All the known calcareous sea floor deposits contain a very considerable percentage of silica and other matters, and if the carboniferous limestones were ever in the condition of modern deep-sea ooze, in order that they should have looked like the chalk they must have lost in some manner or other more than 35 per cent. of impurities. So far as I can understand, much of the carboniferous limestone may have accumulated at no very great depth and on banks within the scour of currents, and their prevalence would account far the comparative absence of sandy sediments in some situations. No traces of atoll formation exist.

With regard to one or two late discoveries relating to the organic remains of the carboniferous limestones, it is necessary to refer you to Moseley's important work amongst the Tabulata. These must now be removed from the true stony corals, and some will be relegated to the Hydrozoa, and others to the Alcyonaria. It is a fact of great interest that Sorby should have noticed that whilst the modern true corals are built up of carbonate of lime in the form of arragonite, the great tabulated forms of old are composed of calcite.

Quite lately Mr. Busk has been investigating the large polyzoa of the genus Heteropora, and I saw, under his manipulation, that this recent and Crag group, with strong palæozoic affinities, is so constructed that the branching tubular organisms of the oldest rocks with perforations in their walls and tabulæ must be included amongst species of genera closely allied to it.

A host of ill-defined tubular forms, such as the Stenoporæ, will thus find a final zoological resting-place.

The arenaceous series of the carboniferous formation in England are not less wonderful than the calcareous. They thin out very rapidly from 10,000 feet in the Burnley district to 100 close to the central barrier in Leicestershire, and it would appear that the sea drift was from the present region of the North Atlantic, along the shores of the swampy coal plant-growing-land.

The arenaceous deposits to the south of the central barrier have the same general relation as those to the north, and the grits of the Welsh and Bristol coal-fields are silicious, and were in all probability derived from the Silurian and old red rocks to their north-west. The culm measures of Somersetshire and Devonshire—those thick deposits with impure thin coals with limestones towards the bases—are of the age of the upper parts of the carboniferous limestones and of the grits of the central area. The evidences in this age of the denudation of granite and other silicious lands, and of more or less distant diffusion of the sediment, extend far and wide from the United Kingdom, a belt of similar rocks being found in south-western and central Europe. It is, moreover, very probable that the upper Vindhyan rocks of Hindostan, those fine sandstones and grits which have yielded the building-stones to the great Gangetic cities, are of the same relative age (or slightly older) as the strata of which so many Yorkshire towns are mainly built.

Whence came the thousands of feet of the sands and shales of the coal measures? is as yet a question which cannot be answered. It appears that very widely distributed deposits of the same kind are comparatively rare amongst them, and that most of the organic deposits, as well as the inorganic sedimentary, do not extend over great breadths, but are more or less lenticular in shape, or thin out or become changed in their lithology. This fact and Sorby's suggestion that the currents which deposited the strata had not any definite course rather tend to the belief in the former presence of a vast delta during that ancient aspect of nature. It is certain that some of the vegetation which subsequently became coal, and many feet of the roof above, were not always formed with great slowness, for stumps and trunks of trees have been found standing where they grew, with their roots in their under-clay and their stems wrapped round with coal, and the shale and gravel above. Moreover, in some places, a series of these interesting relics exists, one set being placed above the others.

With regard to the coal itself, varying as it does in its physical peculiarities, all that has an under-clay grew as vegetation on land. It is at present rather difficult to believe that where a coal-seam is found upon a hard silicious bed without a vestige of clay or of old soil, its plants were rooted there. But the stigmarian roots are not unfrequent in the ganister, and at the present time a peculiar vegetation is growing on the grits to the west of this town with a very small amount of humus intervening. Some coal-seams, especially the cannels, would appear, however, not to have been produced by plants which grew on the rocks beneath, and they are the result of vegetation drifting and becoming water-logged.

In reflecting upon the history of those carboniferous deposits in relation to the subsequent great changes in the physical geography of the earth, the idea that geological histories repeat themselves does not obtain that importance with which it is credited in relation to human events. It is true that there were important triassic, oolitic, wealden, neocomian, and tertiary lands, whose vegetation has been metamorphosed into a kind of coal. But the wonderful depth and the extraordinary vertical repetition of organic and inorganic deposits, of the carboniferous formation, and the remarkable crust movements which enabled them to accumulate, are without subsequent examples.

In conclusion, I must remind you that the volumes of the "Geological Record" give the literature of the carboniferous formation year by year, and that lately a magnificent contribution to the subject has appeared in the memoirs of the Geological Survey of England and Wales in the form of a great volume on the geology of the Yorkshire coal fields, by Prof. Green, one of our vice-presidents, and Mr. Russell. A very concise and excellent geology of the West Riding has also recently been published by Mr. Davis, who is amongst us to-day, and Mr. Bauermann has contributed a capital article on coal to the "Encyclopædia Britannica."

THE FRENCH ASSOCIATION

Montpellier, Sunday

THE French Association for the Advancement of Science met at Montpellier on August 28. The president this year is M. Bardoux, the late Minister for Public Instruction, who has been succeeded by M. Ferry.

His address was devoted entirely to generalities on the necessity of providing a good education for the young. He did not touch upon the great question which agitates the public mind in France in connection with the Ferry Bill. It may be inferred from the strong encomiums passed on M. Jules Simon, that M. Bardoux must be ranked among the opponents to the Ferry Bill.

M. Laissac, mayor of Montpellier, and M. Cazelle, prefect of the Herault, replied to M. Bardoux. M. Saporta, the general secretary, gave an address summarising the results of the last year's meeting, and M. Georges Masson read a financial statement which showed that the capital of the Society amounts to about 300,000 francs. The subsidies paid for research last year amounted to 10,000 francs.

These addresses being the only ones which were given in the name of the Association, and as the presidents of sections gave no official addresses, it will be quite impossible to have any idea of the opinions of the meeting on the topics of the day.

Although but a small city, Montpellier is famous in the annals of science, and in former years its university was deemed a rival to Paris. But in latter years Montpellier has lost much of its *prestige*, although it had the honour to be the birthplace of Auguste Comte. The growing academy of Toulouse disputes with Montpellier the pre-eminence in south-eastern France. Meanwhile the impending meeting of *savants* at Perpignan on the occasion of the inauguration of Arago's statue at the end of September will throw the Montpellier meeting somewhat into the shade, and deprive it of a number of constant and influential members. The interest of the meeting will consist principally in excursions professing to promote ends of great moment for the welfare of the region, viz., the extinction of phylloxera, the construction of an irrigation canal from the Rhone, the local meteorology and botany, which are strongly represented by M. Charles Martius, a brilliant writer, and the director of the celebrated Montpellier plant-gardens. A specimen of the French Atlantic cable now in course of being placed, will be exhibited and explained by M. Gariel, the general secretary of the Council, and the scheme of the French Company explained for the first time. Experiments will be made on electric lighting and the telephone.

The French scientific caravan, officered by MM. Quatrefages, Mortillet, and Broca, to be sent to the Congress of Anthropology at Moscow, is to arrive in Montpellier before the end of the meeting. M. Bergeron, one of the French *savants*, who was present at the Sheffield meeting, has arrived in order to tell the French Association of what was done by her elder sister.

THE SWISS NATURALISTS

THE sixty-second annual meeting of the Swiss naturalists was opened on July 10 at St. Gall. The attendance was comparatively large, no less than two hundred Swiss and twenty-one foreign *savants* being present. Among the latter we notice Prof. Hébert (Paris), Mr. Forrer (San Francisco), Herr Nördlinger (Stuttgart), Dr. Richthofen, and many others.

On Monday, the 11th, the first public meeting was opened at the Grossrathhaus, before a large audience of visitors and ladies, by Dr. Rechsteiner (St. Gall), who gave an address on the recent progress of science; also pointing out the importance of the neighbourhood of St. Gall for the study of geology, and discussing the variety and importance of chemical processes in the life of nature. A second lecture was given by Prof. C. Vogt (Geneva) on the archæopteryx, the interesting reptile-bird which has provoked so animated a discussion among anatomists, and of which we possess only two specimens—that of the British Museum and that newly discovered at Solenhofen, Germany. According to the first, which was very incomplete, this Jurassic animal was considered as a bird, having a beak, nails, and feathers; while the Solenhofen specimen, quite complete, and of which Prof. Vogt exhibited very good photographs, proves undoubtedly that we have to do with a bird-like reptile of the size of a pigeon, which had both scales and feathers, a beak provided with teeth, armed wings, bird-like feet with nails, and a reptile tail consisting of twenty vertebræ. This discovery gave to Prof. Vogt the occasion to make a brilliant address on the origin of species, the adaptation of organisms to the medium they inhabit, and the way in which this adaptation goes on from the periphery to the centre.

Two other lectures were given by M. Victor Fatio, on the phylloxera, and by M. Raoul Pictet on the synthetical theory of calorific phenomena. The naturalists then went to the traditional breakfast served on paper table-cloths with paper napkins, in the beautiful hall of the Kornhalle, the walls of which are decorated with four pictures, by M. Kirchofer, which represent the country of St. Gall during the periods of the lignite (*Schieferkohle*), of the molasse, of the glacial epoch, and of prehistoric man. At two began the sittings of the sections. In the Section of Physics Prof. Hagenbach opened a very interesting philosophical discussion on "centrifugal force," in which discussion he was followed by Prof. Mousson (Zurich), who made a valuable communication on the structure of solid bodies, and on the molecular phenomena which produce the phenomenon of heat. Prof. Pictet (Geneva) explained his researches into the mechanical theory of heat. On the following day Professors Forel (Morges) and L. Soret (Geneva), the indefatigable students of the oscillations of the level of the Lake of Geneva, gave, in the Section of Physics, very interesting communications on that subject, and especially on the rhythmical oscillations described as *seiches*.—M. Dufour having communicated the results of his measurements on the glacier of the Rhone, according to which the lower extremity of this glacier has receded no less than eighty metres (260 feet) during the last two years, a long discussion on the causes of the oscillations of glaciers was engaged between MM. Dufour, Forel, Mousson, and Hagenbach. Finally we notice in the Section of Physics the communications, by M. H. Dufour, on the diffusion of gases; by Prof. Hagenbach on the forms of hail; and by Prof. Colladon (Geneva) on his theories on the optical properties of ice.

The sixty-third meeting will take place next year at Brieg, in the Valley of the Rhone.

SCIENTIFIC SERIALS

The Journal of Physiology (vol. ii. No. 2, issued July).—On the effect of the respiratory movements on the pulmonary circulation, by H. P. Bowditch and G. M. Garland.—On absorption without circulation, by B. F. Lautenbach.—On protagon, by Arthur Gamgee and Ernst Blankenhorn.—On a few further experiments with pituria, by Sydney Ringer and William Murrell.—On the antagonism between pilocarpine and extract of *Amanita muscaria*, by Sydney Ringer and William Murrell.—On some old and new experiments on the fibrin-ferment, by Arthur Gamgee.—On the effect of two succeeding stimuli upon muscular contraction, by Henry Sewall.—There is added a list of titles of books and papers of physiological interest published since December 31, 1878, to date.

Journal of the Royal Microscopical Society (August).—Transactions.—On a new species of excavating sponge (*Alectona millari*), and on a new species of Raphidotheca (*R. affinis*), by H. J. Carter, F.R.S.—On a new genus and species of foraminifera (*Aphrosina informis*), and on the spicules of an unknown sponge, by H. J. Carter, F.R.S.—On the theory of illuminating apparatus employed with the microscope, by Dr. H. E. Fripp.—Observations on *Notommata Werneckii* and its parasitism in the tubes of Vaucheria, by Prof. Balbiani; translated from the *Annales des Sciences Naturelles* (*Zoologie*), 1878.—The record of current researches relating to invertebrata, cryptogamia, microscopy, &c.

The American Naturalist (August).—Adjectives of colour in Indian languages, by Albert S. Gatschet.—On the habits of a species of tarantula (*T. tigrina*?), by Mrs. Mary Treat.—On the formation of Cape Cod, by Warren Upham.—The geological museum of the School of Mines, Columbia College, by Israël C. Russell.

Kosmos, iii. Heft 3, June; Th. Buy, on the estimating of conflicting authorities, or thoughts on the education of the future.—Dr. Otto Kuntze, how the primitive rocks are built-up.—Dr. Dodel-Port, Infusoria as assisting in the fructification in the Florideæ, being a contribution to our knowledge of the interchange of relations between the plant and animal worlds, with illustrations.—Dr. D. F. Weinland, on the statistics of population in the animal kingdom.—T. H. Becker, on the serpent myth.

THE *Revue Internationale des Sciences* (August) contains the following papers:—On the embryogenous vesicle and on parthenogenesis in animals, by Prof. Balbiani.—On the metaphysics of Claude Bernard, by Ch. Letourneau.—On the history of embryological doctrines, by Prof. Kölliker. This is the recapitulation of a German work by the eminent biologist, recently published in a French translation.—On the reality of our perceptions, by Prof. Helmholtz.

SOCIETIES AND ACADEMIES

PARIS

Academy of Sciences, August 18.—M. Daubrée in the chair.—The following papers were read:—On the meridian observations of the minor planets, made at Greenwich and Paris during the second quarter of 1879, by M. Mouchez.—Mr. J. A. Serret presented to the Academy the eighth volume of the works of Lagrange, entitled "Traité de la Resolution des Equations numériques de tous les Degrés, avec des Notes sur plusieurs Points de la Théorie des Équations algébriques."—M. Milne-Edwards presented the complement of the thirteenth volume of his "Leçons sur la Physiologie et l'Anatomie comparées de l'Homme et des Animaux."—Reply by M. Berthelot to M. Wurtz's observations on hydrate of chloral.—On the phenomena of secreting irritation which are apparent in rabbits under the influence of faradisation of the tympanum, by MM. Vulpian and Journiac.—Table of numbers of invariant derivatives of given order and degree, belonging to the binary form of the second order, by Prof. Sylvester.—Methods of graphic calculus; employment of these methods for the revision of projects bearing on the development of the network of French railways, by M. L. Lalanne.—On irrigations and the sulphide of carbon, by M. Mabègue.—On the submersion of vines as a remedy against phylloxera, by M. Faucon.—M. Davin made a communication on the same subject.—The President then stated to the meeting that M. Janssen had been designated to represent the Academy at the inauguration of the statue of François Arago at Perpignan.—The second volume of the "Correspondance politique de Fréderic le Grand" was presented to the Academy by the Berlin Academy of Sciences.—On the integration of irrationals of the second degree, by M. Alexéeff.—Observations on M. Aoust's note on the movement of a straight line in a plane, by M. Ed. Habich.—On atmospheric waves and the monthly lunar equation, by M. Bouquet de la Grye.—On the scintillation of coal-gas flames, by M. F. A. Forel.—On the absorption of nitric oxide by the proto-salts of iron.—On the reaction of chloride of zinc on normal butylic alcohol, by MM. Le Bel and Greene.—Thermal researches on nitroglycerine, by M. H. Boutmy.—On the tenor of urea in urines, by M. G. Esbach.—On the elimination of bromine from bromocitraconic acid, and on a new organic acid, by M. E. Bourgoin.—On scandium, by M. P. Clève.—On the oxy-acids of sulphur, by M. Maumené.—On the composition of slate, by the same.—Note on a means of preventing inundations, by M. A. Sarrand.—On a peculiarity apparent in Jupiter and its satellites, by M. E. Gand.

August 25.—M. Daubrée in the chair.—The following papers were read:—Discovery of two comets, communicated by M. Mouchez. One was discovered by M. Palisa, of Pola, and the other by M. Hartwig, of Strassburg.—On the digestive ferment of *Carica papaya*, by MM. Wurtz and Bouchut. This strong ferment (*papaine*) is easily isolated.—Reply to M. Berthelot's observations, by M. Wurtz.—On a process by which may be obtained in any ball-governor, the degree of isochronism desired, and maintaining this degree for all speeds; general theory, by M. Léauté.—On some multiple stars, according to observations made at the Imperial Observatory of Rio de Janeiro, by M. Cruls.—Researches on the compressibility of gases at high pressures, by M. Amagat. All the gases studied, except hydrogen, presented a minimum of the product pv, situated for each gas about the following pressures (expressed in metres of mercury): nitrogen 50 m., oxygen 100, air 65, carbonic oxide 50, formene 120, and ethylene 65. Thus, as might be expected, the gases that are probably nearest the circumstances determining their liquefaction are those which attain the greatest compressibility.—On the maximum tension and the vapour density of alizarine, by M. Troost. The maximum tension is about 11 mm. at 261° and 20 mm. at 276°. The observed density was, in three experiments, 16·32, 15·0, and 17·8. (The formula $C_{28}H_8O_8$ leads to the calculated density 16·62 for 4 vols. The equivalent of alizarine, then, corresponds to 4 vols.).—Purification of hydrogen, by M. Lionet. This may be effected in the cold state. Oxide of copper arrests, in cold, all the combinations of hydrogen which it may contain as impurities, except carbonised hydrogens.—On the active principle of *Ammi visnaga*, by M. Mustapha.—On a new mode of administration of ether, chloroform, or chloral to the sensitive plant; application to determining the velocity of liquids in the organs of this plant, by M. Arloing. The mode is that of presenting the anæsthetic to be absorbed by the roots. Chloral does not act as an anæsthetic on the sensitive plant; the other two have a similar action to that on animals whether they penetrate by the leaves or the roots. The petioles fall suddenly and successively from below upwards as chloroform absorbed by the roots reaches their insertion. Hence the rate of absorption can be easily calculated. The velocity increases from the base to the top and is one and a half times to twice as great in the petioles as in the stem.—Studies on hydrophobia, by M. Galtier. This relates chiefly on its manifestation in the rabbit, to which it may be transmitted, causing paralysis and convulsions. Salicylic acid administered by hypodermic injection daily did not prevent development of the disorder in the rabbit. The saliva of a mad dog, obtained from the living animal and preserved in water, is virulent, in some cases, even twenty-four hours afterwards.—Researches on animal heat, by M. D'Arsonval. Calorimetry should, scientifically, precede thermometry. The author proposes a new calorimetric method, by which the production of heat in animals can be followed during whole days and weeks. The calorimeter is in an inclosure at constant temperature; and it regulates automatically its own temperature, which remains always invariable.—Researches on the *rôle* of nerve fibres contained in the anastomosis between the superior laryngeal nerve and the recurrent laryngeal nerve, by M. François Franck.—On the malacodermic zoantharia of the coast of Marseilles, by M. Jourdan.—Diffusion of copper in primordial rocks and sedimentary deposits proceeding from them; consequences, by M. Dieulafait.—The falling stars of August, 1879, by M. Chapelas.

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