THURSDAY, JUNE 28, 1888.

THE EARLY CORRESPONDENCE OF CHRISTIAN HUYGENS.

Œuvres Complètes de Christian Huygens publiées par la Société Hollandaise des Sciences. Tome Premier : Correspondance 1638–1656. (La Haye : Martinus Nijhoff, 1888.)

NEVER before, we venture to assert, even in this age of "complete editions," has so colossal a literary monument been raised to the memory of a great man as the edition of the works of Christian Huygens, of which the first instalment now lies before us. In a huge and splendid volume of 621 quarto pages, is contained the correspondence, from his ninth to his twenty-eighth year, of the " young Archimedes," as his friends delighted to call him. Yet out of 2600 documents in the hands of the Commission charged by the Amsterdam Academy of Sciences with the superintendence of the publication, no more than 365 have as yet been printed. Seven additional tomes, at least as massive as that just now issued from the press at the Hague, will be needed to bring to completion the initial section of the comprehensive record. The works of Huygens, edited and inedited, will follow, with an elaborate biography, so that we may safely assume that the present century will not see the end of an enterprise the pecuniary responsibility of which has been generously undertaken by the Scientific Society of Holland.

We have nothing but praise to accord to the manner in which it has so far been conducted. All selective difficulties were indeed spared to the Commission ; for the collection at Leyden was of such exceptional value that their resolution to print everything it contained admitted of no cavil, and was arrived at without hesitation. Room was, however, left for discretion as to the manner of presenting to the public the materials at their disposal ; and it has been wisely exercised. The notes are elucidatory without being obtrusive ; the prefatory remarks are few and to the point ; the indexes (of which there are no less than five) afford a satisfactory clue to a labyrinth of close upon four hundred letters in Latin, French, and Dutch, miscellaneous in their contents, and necessarily chronological in their arrangement. They are of great and varied interest. Scientific history, the dispositions and modes of thought of "men of light and leading" in the seventeenth century, the manners and customs of the time, are all in turn illustrated by them ; above all, their perusal offers singular advantages for studying the development of the powerful and active mind of the protagonist in the life-drama they partially unfold.

Christian Huygens was born at the Hague, April 14, 1629. Every educational advantage which the age could afford was showered upon him. His father, Constantine Huygens, was distinguished as a statesman, a poet, a man of letters, and a musician. Himself a product of the most varied culture, he desired that none of the brilliant faculties early apparent in his two elder sons should rust in disuse. They were accordingly taught to sing and play the lute as well as to compose Latin verses ; they attended the juridical lectures of Vinnius, and studied mathematics under Van Schooten ; they were accomplished in dancing and drawing no less than in Greek, rhetoric, and logic ; they travelled to see the world and improve their manners ; they could, as occasion required, play the courtier, or work as skilled mechanics. The native turn of each was, however, different. Constantine excelled in the lighter branches of literature ; Christian promptly shot ahead of him in geometry. Study and invention went, with him, in this direction, hand in hand. Before he was seventeen, he had begun to strike out original lines of investigation, and the promise of these juvenile essays was discerned, among the first, by Descartes. Mersenne about the same time opened a correspondence with him, and predicted for him greatness beyond that of the towering figure of Archimedes.

He made his *début* in print in 1651 with a treatise on quadratures, to which he appended a refutation of the theorems on the same subject of Gregory of St. Vincent, with the unusual result of gaining (besides many admirers) a friend in the person chiefly interested in the controversy. The little book was received with acclamations of praise. At once and everywhere, the genius of its author was acknowledged. The mathematicians of France, England, and Germany vied with those of Holland in doing him honour. He was lauded as " Vieta redivivus," placed on a level with Pappus and Apollonius, hailed as the great coming light of science. Yet it was not in pure mathematics that his brightest laurels were to be gathered. Many lesser men did more to help on the great revolution in method which signalized his age. He remained, throughout its progress, constant to the ancient models, and looked on, indifferent or averse to changes the full import of which he failed to realize. His extraordinary ability was, however, never more conspicuous than in his successful grappling with problems—such as that of the isochronous curve—unapproachable by geometers of a more common-place type without the aid of the calculus ; and there is reason to think that, had he lived longer, he would have reinforced his powers by its adoption. It appears from a letter of Leibnitz to him, of October 1, 1693, that he was just then, eighteen months before his death, " beginning to find the convenience " of the infinitesimal mode of calculation, and had gone so far as to express publicly his approbation.

The most interesting part of the correspondence now before us refers to Huygens's observations on Saturn. As early as November 1652, we find him making inquiries as to the best manner of preparing and polishing lenses. Assisted by his brother Constantine, he prosecuted the subject with a diligence for which he half apologized to his learned friends, and which produced unwelcome gaps in his communications with them. By the commencement, accordingly, of 1655, he was in possession of a telescope of 12 feet focal length, undoubtedly the best produced up to that date. It showed him, not only the phases of Venus and the satellites of Jupiter, but—March 25, 1655—" aliud quid memorabile," unseen by Fontana or Hevelius, namely a Saturnian moon, afterwards named Titan, the sixth counting outward from the planet, the first in order of terrestrial detection. He concealed and endeavoured to secure his discovery, after the fashion set by Galileo, in an anagram which was widely circulated, and expounded in the following year. The precaution was nevertheless insufficient to prevent a claim to priority being put forward. Dr. Wallis, the Savilian Professor of Geometry, prepared on behalf of his friends Wren and Neile, a storage-battery of fame in the shape of a counter-anagram, which—if Huygens's private notes are to be relied upon—he fraudulently interpreted as an announcement similar in purport to that imparted to him from the Hague. Some unexplained circumstance possibly underlies a transaction on the face of it highly discreditable to our countrymen. The pretensions of the English observers were at any rate quickly and quietly withdrawn, and Huygens was left in undisturbed enjoyment of the credit most justly due to him.

Shortly after his return from Paris, late in 1655, he constructed a telescope of 23 feet, magnifying one hundred times; and the comparison of the observations it afforded him with those of the previous year enabled him at once to penetrate the mystery of Saturn's enigmatical appendages. His hypothesis as to their nature, wrapt up in the customary logogryph, was appended to his little tract on the Saturnian satellite, with an accompanying prediction of the future changes of figure to be expected in the planet. Its verification, however, falls outside the limits of the publication we are at present concerned with. Nor does it include any mention of the novel sight disclosed to Huygens by his improved instrument in the constellation of Orion, where a certain "hiatus" in the firmament permitted (as he supposed) the pure, faint splendour of the empyrean to shine through on his amazed vision.

Huygens had an eminently sane and sagacious mind. His fortunate intuitions were numerous, and the investigations they suggested were singularly solid and complete. A great part of his work was thus fitted to be, and has actually become, the substructure of the modern scientific edifice. He was, however, less happy in the few cases in which, relaxing his habitual prudence, he gave the rein to speculation. His prevision that the measure of discovery in the solar system was filled by the disclosure of Titan, was belied with scarcely civil haste by Cassini's further detections hopelessly overthrowing the numerical balance between six primary and six secondary bodies. And the surmises which constituted the bulk of his "Cosmotheoros" were, for the most part, infelicitous. Yet he reprehended, as woven out of figments, the Cartesian theory of the origin of the universe, and concluded with the wise and memorable words:—"To me it would be much if we could understand how things actually are, which we are far enough from doing. How they were brought about, what they are, and how begun, I believe to be beyond the range of human ingenuity to discover, or even by conjectures to approach."

A. M. CLERKE.

NORWEGIAN GEOLOGY.

Bömmelöen og Karmöen med Omgivelser. Geologisk beskrevne af Dr. Hans Reusch. (Kristiania: Published by the Geological Survey of Norway, 1888.)

THE attention of geologists in all parts of the world has for some years been concentrated upon the crystalline schists, which have so long presented insuperable difficulties to those who would explore their origin. Little by little the darkness has been rising from these ancient foundation-stones of the earth's crust; and though a long time must probably still elapse before their history can be even approximately sketched, there can be no doubt that we are now at last on the right road of investigation. Fresh evidence is continually being obtained from the most widely-separated regions, and each additional body of facts goes to support the view that the schistose rocks are the records of gigantic terrestrial displacements, whereby portions of the crust have been pushed over each other, and so crushed and deformed as to acquire new internal rock-structures. Out of these mechanical movements, with their accompanying chemical transformations, a true theory of metamorphism will no doubt eventually be evolved. In the meantime it is too soon to generalize; what we need is a far larger mass of observations. The subject is a wide one, for it involves the labours of the field-geologist, the petrographer, the mineralogist, the chemist, and the physicist. And only by the united exertions of these fellow-workers can we hope for good progress and solid results.

The most recent contribution to the question of the origin of the crystalline schists has just appeared in the form of a handsome volume, by Dr. Hans Reusch, on the Bömmel and Karm Islands off the mouth of the Hardanger Fjord. It consists of a mass of detailed observations on the structure of the crystalline rocks of that part of the Scandinavian coast, and furnishes an admirable array of fresh data for the study of the problems of regional metamorphism. Dr. Reusch's previous researches on the compressed conglomerates and metamorphosed fossiliferous rocks of the same district were of the utmost value in the discussion of the question, and he now augments these by new details from the surrounding region.

Especially important are the numerous illustrations of the effects of pressure and stretching in the production of the well-known structures of the crystalline schists. The strangely deceptive resemblance to stratification resulting from these processes is exhibited in many examples. Excellent instances are likewise given of the production of foliation in dykes. Eruptive diabases and gabbros are shown to pass into dioritic rocks, and hornblendic schists and granite into various foliated compounds. More novel features of the essay are the careful studies of the deformation and foliation of what were unquestionably at one time ordinary sedimentary deposits—sandstones, conglomerates, and limestones. It is shown, for instance, that in a mass of still recognizable conglomerate the planes of stratification are cut across, almost at right angles, by those of foliation, while the lines that mark the direction of stretching or deformation slant upwards across the latter.

Dr. Reusch brings forward some remarkable observations regarding the connection between conglomerates and granitic rocks. He thinks that in some places what is now granite has resulted from the metamorphism of what was originally a breccia or conglomerate composed of fragments of granite, gneiss, quartzite, and quartz. The quartzite and quartz, being less liable to change, remain still visible, while the granite and gneiss have passed into common granite. In another locality he finds what he believes to be evidence of the passage of a conglomerate into augen-gneiss. Without in any way calling in question the accuracy of his observations, a geologist who has had much experience among the crystalline schists in districts where great thrust-planes and other proofs of powerful displacements prevail, will recall examples of breccias that might at first be taken to be sedimentary masses, but which have eventually proved to be portions of rocks crushed during the disturbances that produced the schistose structure. Coarse pegmatites, for example, may be traced through various stages of comminution, until they pass at length, along the plane of movement, into finely fissile rocks, that in some cases might be mistaken for shales, in others for eruptive rocks with the most exquisitely developed flow-structure. The "eyes" in some augen-gneisses are almost certainly fragments resulting from the crushing of largely crystalline rocks, such as coarse pegmatites.

Dr. Reusch shows that in Scandinavia, as in the north-west and north of the British Isles, the axes of the great terrestrial plications run, on the whole, from north-east to south-west, and that as they have involved Upper Silurian strata in their folds, the movements must be of later date than some part, if not the whole, of the Upper Silurian period. His essay is most welcome as a valuable contribution to one of the most perplexing problems in geology. It once more shows him to be a careful and intrepid field-geologist, and, at the same time, a skilful worker with the microscope. This combination of qualifications fits him in a special manner for the researches to which he has devoted himself with so much ardour and success. His volume is copiously illustrated with figures in the text, and a selection of coloured geological maps. English geologists will also welcome in it a copious English summary of the contents. We may confidently predict that, before long, some of his drawings will be reproduced in the text-books as standard representations of the facts of regional metamorphism. A. G.

TRAVELS IN ARABIA DESERTA.

Travels in Arabia Deserta. By C. M. Doughty. 2 Vols. (Cambridge: University Press, 1888.)

MR. DOUGHTY'S book takes us back to the age of the old travellers. His wanderings were in countries where not only no European had preceded him, but where he had to travel with his life continually in his hand. He travelled alone, and without any of the equipment which the modern explorer considers a necessity of existence, living with the Beduin of the desert, and sharing with them their wretched subsistence. Even the style in which he writes is a style in which it is safe to say no Englishman has written for the last two hundred years, and while it attracts us by its quaintness it makes us not unfrequently wonder what is exactly the author's meaning. Indeed, were it not for the very excellent index, it would often be almost impossible to find one's way through the labyrinth of Mr. Doughty's sentences or to ascertain the exact chronology of his route.

Mr. Doughty seems to have been born under an evil star. While he possesses most of the requisites of a successful traveller—a love of adventure, an insatiable curiosity, indomitable patience, and extraordinary powers of endurance—he lacks, on the other hand, just those qualities which would have smoothed his journey and made his life more comfortable. He is a man, by his own confession, of blunt and plain speech, improvident and forgetful, with an old-world belief in the falsity of Mohammedanism and the Koran, and the iniquity of countenancing them even by a politic word. His explorations took place at the time of the war between Turkey and Russia, when the fanaticism of the Mohammedans of Arabia was excited to the utmost, and he had to leave Damascus at the outset of his journey without any letters or help from the British Consul. The latter, indeed, declared that "he had as much regard of" him, would he "take such dangerous ways, as of his old hat." It is no wonder that Mr. Doughty complains of conduct which caused him "many times come nigh to be foully murdered."

His explorations were conducted in Central Arabia, a country which is less known than Central Africa. He accompanied the Mecca pilgrims as far as "the kella" or fort of Medain, where he lived with the Turkish garrison, visiting from time to time the ruins of Medain Salihh, and taking squeezes of the Nabathean inscriptions there. After some months he joined the nomad Beduin, and wandered with them in various directions, visiting the lava crags on the west and Teyma on the north-east. Eventually he made his way to Háyil in the Nejd—a centre of Wahabi fanaticism—where a sort of settled government was established under Ibn Rashîd. From Nejd he was forwarded, along with some Beduin, to Kheybar, not far to the north of Medineh, where he found himself once more within what was nominally Turkish territory, and was arrested as a spy. Released after a while, he was sent back again, for reasons which are never explained, to Háyil, and here his troubles began. The people of the place would not receive the Christian stranger a second time; his Beduin escort were afraid of bringing him back to Kheybar, and after a series of misadventures he was finally deserted near Aneyza, a town considerably to the south of Háyil. The governor and leading merchants of Aneyza fortunately befriended him, and he at last found his way to Taif and Jedda, though not without being first stripped of the little that still belonged to him, and narrowly escaping with his life.

Mr. Doughty was a careful observer, and he has not only made important additions to our geographical knowledge of Arabia, but also to our geological knowledge of it. The inscriptions he obtained at Medain Salihh and elsewhere have been published by the French Government, and important inferences have been drawn from them. They prove not only that a powerful and civilized State existed in this part of Arabia far on into the Christian era—a fact which was already known—but that this State was Nabathean in its language and character. M. Berger has come to the conclusion that before the rise of Mohammedanism the Arabic of the Koran was the language of Mecca only and the surrounding district, the Nabathean with its Aramaic affinities prevailing in the northern part of Arabia, and the Himyaritic in the south. It seems clear, at all events, that the Nabathean and Himyaritic civilizations once adjoined one another, and that their overthrow marked the triumph of the Beduin children of Ishmael. Since Mr. Doughty's travels, Prof. Euting and M. Huber (who was afterwards murdered by the Hharb Arabs) have visited Medain Salihh and Teyma, and carried away with them a large number of valuable inscriptions. One of these, on a stêlê discovered at Teyma, is now in Paris.

It is interesting to find Mr. Doughty confirming the statement that the final *n* of classical Arabic is still pronounced in the Nejd. His remarks on the diseases prevalent among the natives are also curious, though it is difficult to believe that the ophthalmia from which he had himself suffered is due to drinking cold water before going to bed. Everyone, however, who has had much experience of the Beduin will agree with the character he gives of them. The Egyptians have a proverb: "He who shows a Beduin the way to his door will have long sorrow"; and the traveller is unfortunate who is compelled to intrust himself to their tender mercies.

A. H. S.

OUR BOOK SHELF.

Charts showing the Mean Barometrical Pressure over the Atlantic, Indian, and Pacific Oceans. (London: Published by the Authority of the Meteorological Council, 1888.)

THESE charts are issued in the form of an atlas, and deal in a very complete manner with the barometer means and range of all oceans. The months for which separate charts are given are February, May, August, and November, which have been selected to represent the mean values for winter, spring, summer, and autumn respectively in either hemisphere. In addition to the large charts, which give the material in considerable detail, there are four index charts, on a smaller scale, which exhibit for the same months the isobars, or lines of equal pressure, over the entire globe. These are followed by four charts, on the same scale, showing the range of barometrical pressure. The observations have been derived from logs and documents deposited in the Meteorological Office; logs and remark-books of Her Majesty's ships, furnished by the Admiralty; published narratives of various voyages, and various published results of other nations; also observations at coast stations and islands obtained from all available sources. The number of observations obtained from the Meteorological Office logs for the several oceans are: the Atlantic Ocean, 339,300; the Indian Ocean, 162,000; the Pacific, 88,300.

The barometrical means are given in large figures for areas of 5° of latitude by 5° of longitude, and for the benefit of those who require the material in greater detail smaller figures are given to show the means for areas of 2° of latitude by 2° of longitude, the several means being obtained from the daily averages. The range to the nearest tenth of an inch for each 5° area is placed over the mean for that area, and the number of observations under it; so that the charts not only supply the navigator with all the detail he is likely to require, but afford opportunity of the values being combined by other compilers with material of a similar nature. The isobars are given for each tenth of an inch, and the free use which has been made of the barometrical values for the coast stations greatly enhances the degree of dependence of the several lines. To facilitate the use of the charts for the navigator, the observations are corrected for a constant altitude of 11 feet above the sea, and are reduced to 32° F., but are not corrected for gravity; a table is, however, given on the face of each chart to facilitate this correction.

The general charts which give the isobars of the globe show very conspicuously the prevalence of high-pressure areas in each ocean in each of the four seasons. Change is of course shown in the distribution of pressure, but there is the same tendency to the persistency of high reading. It is seen that these areas oscillate and alter somewhat in intensity with the season, but there are many characteristics in common. The northern Indian Ocean, which is much more surrounded by land, is, however, an exception, the high pressure being situated over the northern part of the ocean, in November and February, and decreasing southwards; whilst in May and August the pressure is lowest in the north and increases southwards, this change being intimately related to the monsoon winds. The charts of range show well the influence of season, the largest differences occurring in the winter months in each hemisphere. In February the range to the west of the British Islands is 2·0 inches, whereas in August it is only one-half as great. The effect of latitude on the amount of range is very evident, the values near the equator being very small. These charts, which have been compiled by Nav.-Lieut. Baillie, R.N., are considerably in advance of any previous work of a similar nature, and will materially aid in explaining the general circulation of the wind over the globe, barometric pressure and wind being so intimately co-related.

Commercial Mathematics. (London: Longmans, Green, and Co., 1888.)

THIS volume is the continuation of a series of books on commercial education, and specially adapted for candidates preparing for the Oxford and Cambridge Schools Examination Board. Arithmetic is first dealt with, the first chapter consisting of an account of the decimal system in France. Moneys, weights, and measures, of Germany, Italy, Spain, Portugal, and Russia, are next discussed, followed by numerous examples; and the first part concludes with a chapter on "Exchange." Algebra is the subject of Part II., which extends as far as quadratic equations, including involution and evolution, and a chapter on the methods of testing algebraical results. The examples are very numerous throughout, and the book ought to be much in demand by the above-mentioned students and others. The volume concludes with a list of results of the various examples.

A Wanderer's Notes. By W. Beatty-Kingston. In Two Vols. (London: Chapman and Hall, 1888.)

FOR about thirteen years Mr. Beatty-Kingston acted as a newspaper correspondent, and in this capacity he had to visit many centres of life on the Continent. In the present volumes he offers a selection from the innumerable pen-and-ink sketches taken during his "multifarious peregrinations." The work, we need scarcely say, has no strictly scientific interest; but it is fresh and amusing, and will no doubt give pleasure to many a reader who has never had an opportunity of seeing the places described in its lively pages. The author is particularly successful in the chapters devoted to Germany, where he seems to have had exceptional means of making himself acquainted with the characteristics of the various classes of the community.

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 intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

The "Sky-coloured Clouds" again.

THESE clouds have reappeared. Last night was the first occasion I have noticed any very distinct display of them this year; but I first saw them on June 12, and again on the 14th; and I think I saw them on June 13 and 17, but was not sure. Previous to that, on May 15 and 16, the green sky, when the sun had set, was of unusual brightness, showing, as I thought, a tendency to the formation of these clouds. Each summer they appear to be growing fainter since they were first generally noticed in 1885.

This year's observations were made in Cornwall, with the exception of last night's, which was at Sunderland.

Sunderland, June 26. T. W. BACKHOUSE.

Earth Pillars in Miniature.

I HAVE taken two photographs of an interesting specimen I obtained from the cliffs here. The stone is composed of very fragile sand-rock containing fragments of flint. A large mass of this became detached from the higher part of the cliff, and some of the pieces chanced to fall on a ledge upon which dry sand was constantly pouring in windy weather. The action of this falling sand wore away all parts of the surface of the stone save those protected by the small embedded fragments of flint, and hence the formation of these miniature pillars.

Owing to the extreme incoherency of the substance, I unfortunately lost one of the most perfect pillars before the photograph was taken.

I conclude that the formation of these pillars was the work of a very few days—perhaps hours. On visiting the spot a few days later, all traces of sand-action had been obliterated by rain. An analogous case was that described by Mr. Blake ("Geol. Miscell. Tracts," 10) as occurring in the Pass of San Bernardino, California; the surface of the granite had been worn by blown sand, but the garnets therein stood out in relief upon long pedicles of feldspar, as a proof of their superior hardness. CECIL CARUS-WILSON.

Bournemouth, June 23.

Egg-masses on *Hydrobia ulvæ*.

CAN any of your readers give me information in regard to the eggs of the Gastropod *Hydrobia ulvæ*?

At a recent excursion of the Biological Society to Hilbre Island, while crossing the great stretch of wet sand which lies in the estuary of the Dee, it was noticed that the surface was covered in some places with vast numbers of *Hydrobia*. Some of these were brought back to the laboratory in their wet sand; and, on being put in a dish of sea-water, the mollusks were found next day to have crawled out of the sand, and I then noticed that nearly every specimen had several little rounded excrescences scattered over the surface of its shell. On examining these, it was found that each was a little mass of small sand grains, in the centre of which was a clear jelly containing several segmenting ova or young embryos. They were undoubtedly molluscan eggs, as I kept them alive until one or two had reached a veliger stage; but did they belong to the *Hydrobia* or to some other mollusk? No other mollusk was, however, noticed in any abundance in the neighbourhood. Has, then, the *Hydrobia* acquired the habit of laying its eggs upon its neighbours' shells, as being the only comparatively stable objects to be found in the fine shifting sands around it? Possibly the method of oviposition of *Hydrobia* is already known, but I have not come across any reference to it. W. A. HERDMAN.

Zoological Laboratory, University College, Liverpool, June 23.

Interpretation of the Differential Equation to a Conic.

MAY I ask, with reference to Mr. Asutosh Mukhopadhyay's geometrical interpretation of the above in NATURE of the 21st inst., how to draw a *curve* at *every* point of which the radius of curvature vanishes, or the curvature is infinite?

Is it not evident that the osculating conic of a conic is the conic itself, and the "aberrancy curve" therefore a *point*, the centre of the conic?

The "sought found," then, is the fact that a conic is a conic!

June 24. R. B. H.

The Nephridia of Earthworms.

THE last number of the *Quarterly Journal of Microscopical Science* has just come into my hands, containing a paper, by Mr. Beddard, on the nephridia of certain earthworms. In November of last year I read a paper, before the Royal Society of Victoria, on the anatomy of the large Gippsland earthworm, *Megascolides australis*. This, which reaches the length of 6 to 8 feet, is, I believe, the largest recorded earthworm, and its nephridial system is of great interest, corresponding closely in many points to that described by Mr. Beddard, in the above paper, as present in *Acanthodrilus multiporus* and *Perichæta aspergillum*. My drawings have been for some time in the lithographers' hands, but as it will still be one or two months before the full paper is published, I should be glad to draw attention to the, in some ways, still more interesting features of the nephridial system in *Megascolides australis*. The nephridia are very evident, and can be divided clearly into two sets.

(1) A great number of small vascular-looking little tufts lining the body-wall, save in the mid-dorsal and ventral lines, especially abundant in the segments containing the reproductive organs (segments 11–19). They have no internal opening.

(2) A series of much larger nephridia, one pair of which only is present in each of the segments in the middle and posterior regions of the body—that is, from about segment 120 to segment 500, or whatever may be the number of the last segment, which varies according to the worm's size. They are placed in the anterior part of each segment, whilst the smaller nephridia form a ring round the body-wall posteriorly. Each one has the usual ciliated funnel opening through the septum into the segment in front.

Throughout the body, where the smaller nephridia occur, there is a network of intra-cellular ducts lying immediately beneath the peritoneal epithelium in connection with the nephridia, and giving off an irregularly arranged series of branched ducts opening externally. Ventrally, also, there appears to be on either side, in the middle and posterior portions of the body, a longitudinal duct running from segment to segment within the most ventral pair of setæ: into this duct open, first, the larger nephridia, and, secondly, the most ventrally placed small nephridia of the same segment; the latter, again, are united with the network of ducts connected with the ring of smaller nephridia.

In the case of the latter there appear to be two somewhat differently formed sets of external openings. All over the body, except in the clitellar region, where there is a great glandular development in the body-wall, the duct leading to the exterior is intercellular, small, and composed of minute cubical cells; in the clitellar region, on the other hand, the duct, though similarly intercellular, is much swollen out, slightly coiled, and always provided with a distinct coiled blood-vessel running by its side: its lining cells form a flattened epithelium.

The external opening itself is formed of cells of the epidermis, so modified as to present very much the external appearance of a taste-bulb—that is, they form a sphere with the cells thicker in their middle parts, and the two ends attached to the poles of the sphere, the duct passing right up through the centre. This structure of the external opening is common to all the ducts in the body, but is more clearly made out in the case of those referred to.

The large size and ciliated funnels of the paired nephridia distinguish these clearly from the more numerous smaller ones, which are devoid of internal openings, and are without a doubt homologous with those of *Acanthodrilus* and *Perichæta*. At the same time it is important to note that histologically the network of ducts and the longitudinal duct, which are intimately connected with each other, are precisely similar in structure, and, *a priori*, might be expected to have a similar origin, *i.e.* to be derived from the same germinal layer.

Leaving out of consideration at present the question dealt with by Mr. Beddard and others as to the homology of the larval nephridia of Chætopods, and assuming the existence of a genetic relationship between the adult nephridial system of Platyhelminths and Chætopods, the following questions suggest themselves with regard to the various nephridial structures present in different forms:—

(1) Are the longitudinal ducts in *Lanice*, the embryo of *Lumbricus* and *Megascolides*, homologous with each other? Before this can be determined the development of each must be known.

(2) Granted, of which there can be little doubt, that the smaller nephridia of *Megascolides* are homologous with the nephridia of *Perichæta* and *Acanthodrilus*, are not the large nephridia of the former, which are completely wanting in both

of these, homologous with the nephridia of other worms, such as *Lumbricus*, to which they are at all events suspiciously similar in arrangement and structure?

(3) What is the relationship of the large to the smaller nephridia? Are they modifications of the latter, or independent later developments?

(4) In either case the Platyhelminth system must be more closely represented by the small nephridial bodies devoid of internal openings and provided with a network of ducts such as is found in *Perichæta*, *Acanthodrilus*, and *Megascolides*, than by the more specialized paired nephridia of such a form as *Lumbricus*.

Possibly the course of development as represented in living forms may be somewhat as follows:—

(1) A series of numerous nephridia present in each segment devoid of internal openings, and connected by a continuous network of ducts, as in *Perichæta*.

(2) The aggregation of these smaller nephridia into tufts in various parts, as in the posterior region of *Acanthodrilus*; the subsequent enlargement of certain of these nephridia and the acquirement by them of secondary internal openings. It is interesting to note in *Megascolides* that in the anterior part of the body, where the small nephridia are scattered over the whole body-wall of the segment, large nephridia are absent, whilst they are present in the posterior region, where the small nephridia are confined to a ring in the posterior part of the segment. In this case, as the nephridia become aggregated into tufts in the anterior part, the ducts connecting them with those in the posterior region of the segment next in front will become fewer, until when, as in *Megascolides*, only a single, modified, large nephridium remains on either side anteriorly, there will be simply one duct from segment to segment uniting with a network of ducts in the region where the small nephridia still persist.

It is interesting to note that the aggregation of the smaller nephridia, and on this supposition the modification of certain of them to form the larger ones, commences in the posterior region of the body.

In certain worms, such as *Acanthodrilus*, the connection of the network of ducts from segment to segment seems to have been lost, at any rate in the adult: aggregation of these in the neighbourhood of the setæ, and subsequent modification, would give rise to a certain number of nephridia in each segment without any longitudinal duct.

(3) The next stage is reached in such a form as *Lanice*, where the longitudinal duct persists, but all trace of the smaller nephridia is lost.

(4) The final stage is present in most earthworms where, in the adult, all traces of both small nephridia and longitudinal duct are lost, though the latter is present, as in *Lumbricus*, during development.

These lead to three conclusions, two of which are practically identical with those of Mr. Beddard:—

(1) That the smaller nephridia without internal openings, irregularly scattered, and with a network of ducts such as are seen in *Acanthodrilus*, *Perichæta*, and *Megascolides*, are homologous with the nephridial system of Platyhelminths.

(2) That the larger nephridia typical of most earthworms are secondary modifications of certain of the smaller ones subsequent to their aggregation into groups; the modified ones acquiring each an internal opening.

(3) That there is no homology between the longitudinal duct of *Lumbricus*, *Lanice*, *Megascolides*, &c., with that of the Platyhelminths, since it has only been developed in the above forms in connection with the larger nephridia and as a modification of the original network, and has thus had its origin within the Chætopod group. W. BALDWIN SPENCER.

Melbourne University, May 3.

Strange Rise of Wells in Rainless Season.

MY attention has been directed to a letter published by you a few weeks ago (May 31, p. 103) under the above heading. It would appear that there is something mysterious in the eyes of the author of the communication in question in the fact that the water in two wells at Fareham rose several feet in the month of March, as he states, "after a continuance of north-east wind, *without rain*, but with half a gale blowing"; so that it would appear that there was some connection between the north-easterly gale and the rise of the water.

In this, however, the author is entirely mistaken; the rise of water in the wells in question is nothing more than the ordinary seasonable rise due to percolation. For twelve years past I have been carrying on constant observations of the underground water-supplies in various parts of this country, and it is quite true, as mentioned by the writer of the letter, that ordinarily the water in wells rises in the winter and falls in the summer; but this is by no means an exceptional rule, for in the present season there have been two low waters, the last of which occurred in the southern counties on the 8th of March in the present year. After that date commenced a very wet period, and before the end of the month over 2½ inches of rain had absolutely passed through the ground as measured by my percolation gauges. The water in a well on the Surrey hills, which had been falling up to March 8, rose before the end of the month over 30 feet, which rise was entirely due to the replenishment from rainfall. I may point out that there are many wells at the present time in which the water is still rising, while in others in the same districts the water is falling, for the simple reason that as a rule underground water follows the same law as water flowing in a river, and that the floods or high waters descend from the highest to the lowest districts, so that at present in wells situated in high positions the water is falling, while the crest of the wave of high water in the same watershed has not yet been reached in the lower levels of the district.

That the water in wells *does* fluctuate under certain conditions of the wind there is no doubt, as I have already drawn attention both to the fluctuations which take place in the water-levels of wells under barometric pressure and also in the volume of water discharged from the ground with a fall of the barometer. It should be noted that the rise of water in wells when due to barometric changes coincides with the fall of the barometer. Now a north-easterly wind as a rule is accompanied by a high barometer, and therefore is not likely to influence the rise of water in a well. During the month of March the rainfall was above the average, while there were comparatively few days with easterly winds, the only time when it could be termed a half-gale from the north-east occurring on the 19th of March, by which time the water in all the wells had made a considerable rise, due simply to ordinary percolation. Thus there is no mystery attaching to the rising of the water in these wells at Fareham. The rise simply took place from the replenishment of the springs, which this year occurred at a period somewhat different from ordinary years. BALDWIN LATHAM.

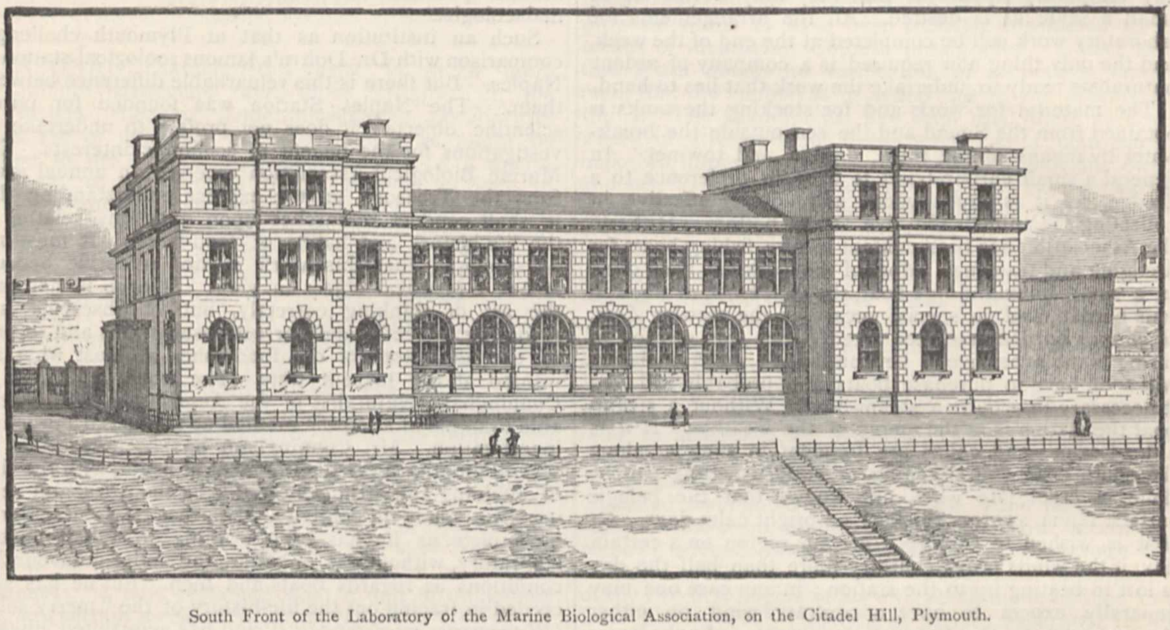
7 Westminster Chambers, Westminster, June 21.

THE OPENING OF THE MARINE BIOLOGICAL LABORATORY AT PLYMOUTH.

THE Laboratory at Plymouth, which is now ready for work, is remarkable as being the first institution in this country designed purely for scientific research which has been originated and firmly established by the efforts of scientific men appealing to the generosity and confidence of wealthy individuals and corporations who desire the progress of knowledge for practical ends and the general good of the community.

It may be said that the Marine Biological Association will begin its active career on and after Saturday next. On that day Prof. Flower will, on behalf of the Association, declare that the Laboratory at Plymouth, which is now complete, is open for the purposes of biological research. The opening of the Laboratory may be said to mark an epoch in English zoological science, just as the opening of the Stazione Zoologica at Naples, which is essentially a German undertaking, marked an epoch in German science. It is true that small sea-side laboratories have already been established in the United Kingdom—at Granton, St. Andrews, and Liverpool Bay; but none of them can compare with the present undertaking in size and importance, and none can offer such advantages to the investigator.

The present institution, it may be remembered, is historically the outcome of the International Fisheries Exhibition held in London in 1883. That Exhibition served partly as an amusement to Londoners, but it also performed a far more important service—it directed people's minds towards the importance of our fisheries, and made them in some slight degree acquainted with the conditions under which those fisheries are worked. At the close of the Exhibition a large balance was left in the hands of its promoters, and it was hoped by many leading men of science that the money thus obtained would be utilized, in part at least, for the purpose of encouraging investigations upon the habits and economy of food-fishes. But the money was appropriated to other purposes, excellent in themselves, though useless as a means of promoting the welfare of the fishing industry. Prof. Lankester, however, nothing daunted by this want of success in obtaining funds from the surplus of the Fisheries Exhibition, and feeling that it was time to strike whilst people's minds were awakened to the importance of our fisheries and to the lack of scientific knowledge concerning them, determined to found an Association for the purpose of encouraging the study of the marine fauna of the British coasts, and with the consent and co-operation of the officers of the Royal Society called a meeting for this purpose in the rooms of the Society on March 31, 1884. The meeting was eminently successful. The Duke of Argyll proposed a resolution to found the Marine Biological Association of the United Kingdom, and was supported by the most eminent biologists in the country. An appeal was made for subscriptions in aid of the Association's projects, and was soon liberally responded to. His Royal Highness the Prince of Wales graciously consented to be patron of the Association, and gave liberally to its funds; the scientific Societies, the City Companies, the Universities, and finally Her Majesty's Government, joined the list of subscribers; and in a short time the Association was in a position to undertake the building of a laboratory. After some debate as to the most suitable locality for a laboratory, Plymouth was selected, partly because it is a large and important fishing port, partly because the richness of the marine fauna of the Sound and neighbouring shores was extolled by such eminent authorities as the late Dr. Gwyn Jeffreys, Mr. C. Spence Bate, and Prof. Charles Stewart. The Association was fortunate in securing a magnificent site for the Laboratory from the War Office. For this site, than which a better could not be found, the Association is greatly indebted to the Earl of Morley,



South Front of the Laboratory of the Marine Biological Association, on the Citadel Hill, Plymouth.

then Under-Secretary of State for War, and to Sir Andrew Clarke, Inspector-General of Fortifications. The site granted is that part of the fosse of the Citadel lying to the south of the portion of the Citadel wall known as King Charles's Curtain; it has a frontage towards the sea of 265 feet, and extends some 240 feet southwards of the Citadel.

The Laboratory which has been erected upon this site is admirably adapted to the purposes of the Association. It is, indeed, more than a laboratory, it is also an aquarium, whose tanks are extensive and fitted with every improvement that modern science can suggest. The total cost of building, machinery, and fittings, including all fees, has been about £12,500. The structure comprises a central portion with a wing at either end. The east wing is almost wholly taken up by the residence of the Director, and needs no further comment. The west wing has on the ground floor the caretaker's rooms, and a receiving-room into which the results of the day's fishing will be brought for examination. On the first floor are chemical and physiological laboratories, and on the second floor a library, a work-room, and lavatory. The main part of the building contains on the ground floor the aquarium or tank-room, and on the first floor the large laboratory. The tank-room is fitted with slate and glass tanks, of which one on the northern side is a noble window tank, 30 feet in length, 9 feet in breadth, and 5 feet deep. There are three large window tanks on the north side, nine smaller window tanks on the south side, and a series of five table tanks in the middle of the room. The tanks are supplied with salt water from two reservoirs, capable of holding 50,000 gallons each. From these the salt water is led by means of pumps through vulcanite pipes into the tanks; the openings of the pipes are placed rather more than a foot above the level of the water in the tanks, and are provided with nozzles through which the water is forced at high pressure, so as to form jets descending deep into the tank and carrying with them a quantity of atmospheric air. Circulation has been established in the tanks for the last fortnight, and there is every reason to be satisfied with the arrangements for aërating the water. The jets carrying down the air deep into the water of the tank cause it to be filled with minute bubbles so as to resemble champagne, and all the animals that have hitherto been placed in the tanks are thriving in a remarkable manner, which is the more surprising as new tanks are generally supposed to be highly injurious to organisms introduced into them at an early a date. It would be too much to expect that tanks which have been so lately put up should be fully stocked within a fortnight, nevertheless they will present to the visitors on Saturday next a sufficiently interesting collection of local marine forms. For the rest the tank-room is a plain room, without any attempt at ornamentation. It is felt that the scientific nature of the institution must be kept in the foreground, and therefore nothing has been done to make the aquarium a place of popular amusement.

The main laboratory is at present fitted with seven compartments, each to contain a single naturalist, along its north side. When the necessity arises, similar compartments will be placed along the south side. In the centre of the room is a series of slate and glass tanks supplied with salt water from the circulating pumps. Beneath these a convenient shelf has been arranged, so that naturalists will be able to arrange for themselves any temporary apparatus that they may devise on as small a scale as is desired. All the arrangements for laboratory work will be completed at the end of the week, and the only thing now required is a company of ardent naturalists ready to undertake the work that lies to hand.

The material for work and for stocking the tanks is obtained from the Sound and the sea outside the breakwater by means of the trawl, dredge, and tow-net. In general a small shrimp-trawl is used in preference to a dredge, as it is much wider and equally effective in collecting the animals that live at the bottom. Hitherto the Association has been content to hire fishing-boats for dredging and trawling. Most of the work has been done in a small hook-and-line boat, the *Quickstep*, of about 6 tons burden, and on special occasions the trawler *Lola*, of 50 tons burden, has been hired. But this method of hiring is too expensive to be continued; the Association will soon have to purchase boats, and probably will find it necessary to acquire a steam-boat. Without a steam-boat the station is at the mercy of the weather. If it is a dead calm—and calms are frequent in summer along the south coast—no dredging or surface netting can be done, a cruel fate when one knows that the pelagic surface fauna swarms thickest on bright calm days. Or if it is wished to explore a certain region on a certain day, if the winds prove contrary more than half the day is lost in beating up to the station; in any case one may generally expect to have a contrary wind on either the outward or the homeward journey. Such losses of time and material are most prejudicial to an institution like the Marine Biological Association. A steam-launch has been found necessary at all other marine stations. Dr. Dohrn has two, the *Johannes Müller* and the *Francis Balfour*, at Naples; and the Granton Station is well provided for by the steam-yacht *Medusa*. But the funds of the Association have been well nigh exhausted in the building of the Laboratory. If a steam-launch is found requisite, it will be necessary to make another appeal to its friends, which, let it be hoped, will be as heartily responded to as the first appeal for funds for building the Laboratory.

It was stated in the early part of this article that the Association would begin its active existence on the 30th. It would have been more proper to say its active public existence, for its staff has been active for some time past. Under the guidance of Mr. W. Heape, the late Superintendent, a careful though necessarily incomplete exploration of the Sound has been made, and numbers of animals have been identified, preserved, and put aside for future reference. Mr. Heape has also drawn up a complete list of the fauna and flora of the Sound, as recorded up to the present date, and a very formidable list it is.[1] Botanists will note that there are more than 250 species of marine Algæ recorded from the neighbourhood, and some of them are extremely rare. Zoologists will see that there is an unlimited field in certain groups, particularly in the Crustacea and the Mollusca, but that some of the most interesting forms, the "pets of the laboratory," such as Amphioxus and Balanoglossus, are absent. But to say that they are absent means only that other less familiar forms are present, and that these old favourites have not been recorded. A good authority states that Amphioxus can be found in the immediate neighbourhood, whilst it is confidently expected that both Balanoglossus and Amphioxus can be introduced from the Channel Isles, and kept alive in the tanks. The zoologist need not fear that he will be hindered by the poverty of the fauna; there is material enough and to spare. The remarkable Hydroid, *Myriothela*, occurs at low-tide mark in considerable quantities. The interesting Actiniæ, *Edwardsia* and *Peachia*, are to be found. Appendiculariæ and Sagittæ are taken in hundreds in the tow-net. *Antedon rosaceus* is abundant a quarter of a mile from the Laboratory, and magnificent specimens of Pinna will attract the interest of the malacologist.

Such an institution as that at Plymouth challenges comparison with Dr. Dohrn's famous zoological station at Naples. But there is this remarkable difference between them. The Naples Station was founded for purely scientific objects: it does not profess to undertake investigations for the benefit of economic interests. The Marine Biological Association receives an annual grant from the Treasury, on the express understanding that it shall conduct researches upon questions relating to the life-history and habits of food-fishes. It must not be supposed that this work is not scientific because it has a practical object in view. Science is not only the art of thinking correctly, but of observing and recording correctly, and correct observations and records of the life-history of our food-fishes are just what are wanted at the present time. The work of Mr. J. T. Cunningham, Naturalist of the Association, is an admirable example of scientific method as applied to a practical investigation. Mr. Cunningham has been working for several months at the development of fishes, with the view of obtaining and artificially fertilizing their ova and rearing their young in captivity. His results are necessarily incomplete, as he has been working in a half-finished laboratory, without gas or water, and under unfavourable conditions as regards boats and men. But he has succeeded in tracing out the life-history of the "merry sole" (*Pleuronectes microcephalus*), and has acquainted himself with such important facts concerning the development of the common sole, that he confidently expects to be able to hatch out the young next season, his experiments this year having failed only for want of the proper apparatus. He has also recorded the interesting fact that the herring spawns continuously from January to June in the Channel, and appears to have no definite breeding-season as it has in northern waters; and has discovered important facts relative to the breeding of the mackerel, conger, and pilchard, which will be made public as soon as his researches are complete. He has now stocked one of the large tanks in the aquarium with conger, and hopes in a short time to give a final opinion on the obscure question of the breeding of this fish. Not less interesting than Mr. Cunningham's researches are those of Mr. Weldon on the breeding of the common lobster, and the rock-lobster or craw-fish (*Palinurus*). Another of the tanks in the aquarium is occupied by the "berried" females of these forms, whose bright colours and active movements are as attractive to the casual spectator as their study is interesting to the zoologist and fisherman. So much has been

[1] Mr. Heape's list will be published in the forthcoming number (No. II.) of the Journal of the Marine Biological Association.

done already by Messrs. Cunningham and Weldon under the most unfavourable conditions that it cannot but be anticipated that when a number of investigators are working under favourable conditions on different groups, but with a common object in view, results of the greatest scientific and practical importance will accrue.

The ceremony on Saturday will be interesting and important. Many of the leading biologists in England will be present, but unfortunately the eminent President of the Association, Prof. Huxley, will be absent on account of ill-health, and so, unfortunately, will Prof. Moseley, one of its most ardent and generous supporters. The Fishmongers' Company have added to their munificent patronage of the institution by undertaking the entertainment of the numerous guests who have been invited to the ceremony; and the Association will be launched on its career of usefulness in a manner worthy of its aspirations, and satisfactory in the highest degree to its energetic promoters. G. C. B.

PERSONAL IDENTIFICATION AND DESCRIPTION.[1]

II.

PERSONAL characteristics exist in much more minute particulars than those described in the last article. Leaving aside microscopic peculiarities which are of unknown multitudes, such as might be studied in the 800,000,000 specimens cut by a microtome, say of one two-thousandth part of an inch in thickness, and one tenth of an inch each way in area, out of the 4000 cubic inches or so of the flesh, fat, and bone of a single average human body, there are many that are visible with or without the aid of a lens.

The markings in the iris of the eye are of the above kind; they have been never adequately studied except by the makers of artificial eyes, who recognize thousands of varieties of them. These markings well deserve being photographed from life on an enlarged scale. I shall not dwell now upon these, nor on such peculiarities as those of hand-writing, nor on the bifurcations and interlacements of the superficial veins, nor on the shape and convolutions of the ear. These all admit of brief approximate description by the method explained in the last article—namely, by reference to the number in a standard collection of the specimen that shall not differ from it by more than a specified number of units of unlikeness. I fully explained what a unit of unlikeness was, and certain mechanical means by which a given set of measures could be compared with great ease and by a single movement with every set simultaneously, in a large standard collection of sets of measures.

Perhaps the most beautiful and characteristic of all superficial marks are the small furrows with the intervening ridges and their pores that are disposed in a singularly complex yet even order on the under surfaces of the hands and the feet. I do not now speak of the large wrinkles in which chiromantists delight, and which may be compared to the creases in an old coat or to the deep folds in the hide of a rhinoceros, but of the fine lines of which the buttered fingers of children are apt to stamp impressions on the margins of the books they handle, that leave little to be desired on the score of distinctness. These lines are found to take their origin from various centres, one of which lies in the under surface of each finger-tip. They proceed from their several centres in spirals and whorls, and distribute themselves in beautiful patterns over the whole palmar surface. A corresponding system covers the soles of the feet. The same lines appear with little modification in the hands and feet of monkeys. They appear to have been carefully studied for the first time by Purkinje in 1822; since then they have attracted the notice of many writers and physiologists, the fullest and latest of whom is Kollman, who has published a pamphlet upon them, "Tastapparat der Hand" (Leipzig, 1883), in which their physiological significance is fully discussed. Into that part of the subject I am not going to enter here. It has occurred independently to many persons to propose finger-marks as a means of identification. In the last century, Bewick in one of the vignettes in the "History of Birds" gave a woodcut of his own thumb-mark, which is the first clear impression that I know of. Some of the latest specimens that I have seen are by Mr. Gilbert Thomson, an officer of the American Geological Survey, who, being in Arizona, and having to make his orders for payment on a camp suttler, hit upon the expedient of using his own thumb-mark to serve the same purpose as the elaborate scroll engraved on blank cheques—namely, to make the alteration of figures written on it, impossible without detection. I possess copies of two of his cheques. A San Francisco photographer, Mr. Tabor, made enlarged photographs of the finger-marks of Chinese, and his proposal seems to have been seriously considered as a means of identifying Chinese immigrants. I may say that I can obtain no verification of a common statement that the method is in actual use in the prisons of China. The thumb-mark has been used there as elsewhere in attestation of deeds, much as a man might make an impression with a common seal, not his own, and say, "This is my act and deed"; but I cannot hear of any elaborate system of finger-marks having ever been employed in China for the identification of prisoners. It was, however, largely used in India, by Sir William Herschel, twenty-eight years ago, when he was an officer of the Bengal Civil Service. He found it to be most successful in preventing personation, and in putting an end to disputes about the authenticity of deeds. He described his method fully in NATURE, in 1880 (vol. xxiii. p. 76), which should be referred to by the reader; also a paper by Mr. Faulds in the next volume. I may also refer to articles in the American journal *Science*, 1886 (vol. viii. pp. 166 and 212).

The question arises whether these finger-marks remain unaltered throughout the life of the same person. In reply to this, I am enabled to submit a most interesting piece of evidence, which thus far is unique, through the kindness of Sir Wm. Herschel. It consists of the imprints of the two first fingers of his own hand, made in 1860 and in 1888 respectively; that is, at periods separated by an interval of twenty-eight years. I have also two intermediate imprints, made by him in 1874 and in 1883 respectively. The imprints of 1860 and 1888 have now been photographed on an enlarged scale, direct upon the engraver's block, whence Figs. 9 and 11 are cut; these woodcuts may therefore be relied on as very correct representations. Fig. 10 contains the portion of Fig. 9 to which I am about to draw attention. On first examining these and other finger-marks, the eye wanders and becomes confused, not knowing where to fix itself; the points shown in Fig. 10 are those it should select. They are those at which each new furrow makes its first appearance. The furrows may originate in two principal ways, which are not always clearly distinguishable: (1) the new furrow may arise in the middle of a ridge; (2) a single furrow may bifurcate and form a letter Y. The distinction between (1) and (2) is not greatly to be trusted, because one of the sides of the ridge in case (1) may become worn, or be narrow and low, and not always leave an imprint, thus converting it into case (2); conversely case (2) may be changed into (1). The position of the origin of the new furrow is, however, none the less defined. I have noted the furrow-heads and bifurcations of furrows in Fig. 9, and shown them separately in Fig. 10. The reader will be able

[1] The substance of a Lecture given by Francis Galton, F.R.S., at the Royal Institution on Friday evening, May 25, 1888. Continued from p. 177.

to identify these positions with the aid of a pair of compasses, and he will find that they persist unchanged in Fig. 11, though there is occasional uncertainty between cases (1) and (2). Also there is a little confusion in the middle of the small triangular space that separates two distinct systems of furrows, much as eddies separate the stream

FIG. 9.—Enlarged impressions of the fore and middle finger tips of the right hand of Sir William Herschel, made in the year 1860.

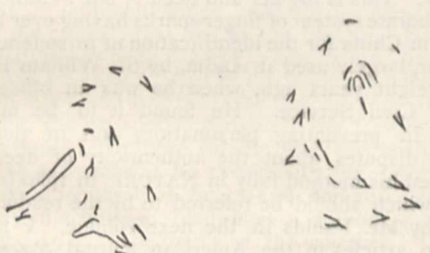


FIG. 10.—Positions of furrow-heads and bifurcations of furrows, in Fig. 9.

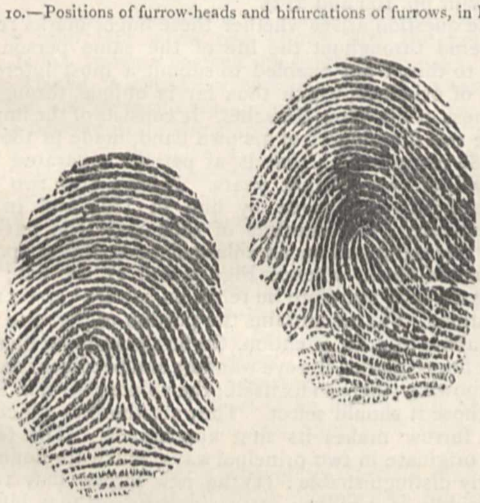


FIG. 11.—Enlarged impressions of the fore and middle finger tips of the right hand of Sir William Herschel, made in the year 1888.

lines of adjacent currents converging from opposite directions. A careful comparison of Figs. 9 and 11 is a most instructive study of the effects of age. There is an obvious amount of wearing and of coarseness in the latter, but the main features in both are the same. I happen to possess a very convenient little apparatus for recording the positions of furrow-heads. It is a slight and small, but well-made wooden pentagraph, multiplying five-fold, in which a very low-power microscope, *with coarse cross-wires*, forms the axis of the short limb, and a pencil-holder forms the axis of the long limb. I contrived it for quite another use—namely, the measurement of the length of wings of moths in some rather extensive experiments that are now being made for me in pedigree moth-breeding. It has proved very serviceable in this inquiry also, and was much used in measuring the profiles spoken of in the last article. Without some moderate magnifying power, the finger-marks cannot be properly studied. It is a convenient plan, in default of better methods, to prick holes with a needle through the furrow-heads into a separate piece of paper, where they can be studied without risk of confusing the eye. There are peculiarities often found in furrows that do not appear in these particular specimens, to which I will not further refer. In Fig. 10 the form of the origin of the spirals is just indicated. These forms are various; they may be in single or in multiple lines, and the earlier turns may form long loops or be nearly circular. My own ten fingers show at least four distinct varieties.

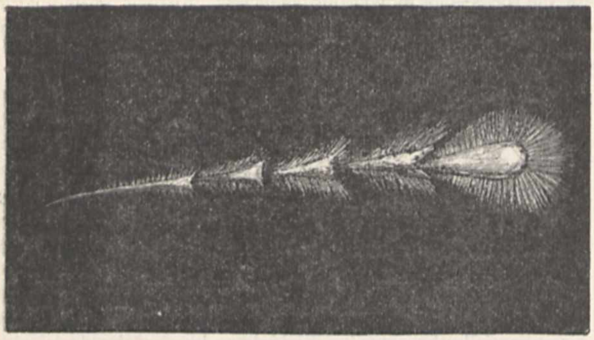
Notwithstanding the experience of others to the contrary, I find it not easy to make clear and perfect impressions of the fingers. The proper plan seems to be to cover a flat surface, like that of a piece of glass or zinc, with a thin and even coat of paint, whether it be printers' ink or Indian ink rubbed into a thick paste, and to press the finger lightly upon it so that the ridges only shall become inked, then the inked fingers are pressed on smooth and slightly damped paper. If a plate of glass be smoked over a paraffin lamp, a beautiful negative impression may be made on it by the finger, which will show well as a lantern transparency. The blackened finger may afterwards be made to leave a positive impression on a piece of paper, that requires to be varnished if it is to be rendered permanent. All this is rather dirty work, but people do not seem to object to it; rivalry and the hope of making continually better impressions carries them on. It is troublesome to make plaster casts; modelling-clay has been proposed; hard wax, such as dentists use, acts fairly well; sealing-wax is excellent if the heat can be tolerated; I have some good impressions in it. For the mere study of the marks, no plan is better than that of rubbing a little thick paste of chalk ("prepared chalk") and water or sized water upon the finger. The chalk lies in the furrows and defines them. They could then be excellently photographed on an enlarged scale. My own photographic apparatus is not at hand, or I should have experimented in this. When notes of the furrow-heads and of the initial shape of the spiral have been made, the measurements would admit of comparison with those in catalogued sets, by means of a numerical arrangement, or even by the mechanical selector described in the last article. If a cleanly and simple way could be discovered of taking durable impressions of the finger tips, there would be little doubt of its being serviceable in more than one way.

In concluding my remarks, I should say that one of the inducements to making these inquiries into personal identification has been to discover independent features suitable for hereditary investigation. It has long been my hope, though utterly without direct experimental corroboration thus far, that if a considerable number of variable and independent features could be catalogued, it might be possible to trace kinship with considerable certainty. It does not at all follow because a man inherits his main features from some one ancestor, that he may not also inherit a large number of minor and commonly overlooked features from many ancestors. Therefore it is not improbable, and worth taking pains to inquire whether each person may not carry visibly about his body undeniable evidence of his parentage and near kinships.

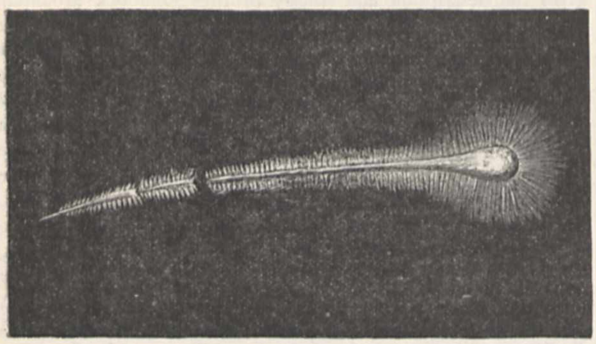
A MAGNIFICENT METEOR.

WE have received from Mr. C. Weatherall Baker (who writes from Penang) the following notes on a magnificent meteor seen from the s.s. *Prometheus* in longitude 62° E., latitude 10° 20′ N., at 10.40 p.m. on Friday, April 6, 1888:—

"It rose from the north by west horizon, and, passing behind a small cloud, travelled in a south by east direction, being at one period of its transit immediately above the ship. Sketch A represents the meteor when in that position. It traversed the whole arc of 180°, and was visible from first to last with the exception of the time when it was behind the small cloud before mentioned, the transit occupying about 30 seconds. When directly above the ship, the head appeared as near as possible the size of the moon when at its height, and the tail streamed out as in the sketch, to a length of about 15 diameters of the head. It was a brilliant white, and threw shadows on the deck as dense as those caused by the moon at the full. Sketch B represents the meteor as it appeared a few degrees above the horizon on its upward course, and on reaching the same distance above the south by east horizon it was simply a dull red ball with no tail whatever. Captain J. K. Webster, of the s.s. *Prometheus*, who has had many years' experience in most parts of the world, tells me that he has never seen a meteor in any way equalling this one for size or brilliancy."



A.—View as seen directly over ship at 10.40 p.m.



B.—View as seen shortly after appearing.

NOTES.

THE Council of the Royal Meteorological Society have issued a circular requesting that photographs of lightning may be sent to them. In response to a similar appeal last year, about sixty photographs of lightning-flashes were received from various parts of Europe and America. The Council remind photographers, amateur and professional, that the photography of lightning does not present any particular difficulties. "If a rapid plate, and an ordinary rapid lens with full aperture, be left uncovered for a short time at night during a thunderstorm, flashes of lightning will, after development, be found in some cases to have impressed themselves upon the plate. The only difficulty is the uncertainty whether any particular flash will happen to have been in the field of view. A rapid single lens is much more suitable than a rapid doublet; and it is believed that films on paper would effectually prevent reflection from the back. The focus should be that for a distant object; and, if possible, some point of landscape should be included to give the position of the horizon. If the latter is impossible, then the top of the picture should be distinctly marked. Any additional information as to the time, direction in which the camera was pointed, and the state of the weather, would be very desirable."

THE Kew Bulletin for June contains, besides an account of the manufacture of quinine in India, papers on "Job's Tears" (the round, shining fruits of a grass widely distributed in tropical countries, and used by the Karens for the decoration of clothing); on China grass or Ramie, the fibre of which, if it could be extracted and cleaned at a cheap rate, would have great economic value; and on a new botanical station at Lagos, which promises to exercise a very favourable influence on the industrial development of the West African colonies.

SOME time ago the Agassiz Association appointed a Committee to arrange for a seaside meeting during the present summer. This Committee, according to *Science*, proposes that the meeting shall be known as the "Agassiz Seaside Assembly." Its membership is to consist of such persons as shall send their names to the secretary before the opening of the assembly, or such as shall be elected members according to by-laws adopted afterwards. It is intended that the organization shall be made permanent. A six-days' session will be held this year, at Asbury Park, N.J., provided suitable accommodations can be secured at that place in the month of August. The subjects to be discussed this year will be principally botany and entomology, under the direction of such practical specialists as can be secured. The work is to include several field-day excursions with experienced guides.

THE heat in India lately has been unprecedented, in consequence of the delay of the monsoon. On June 24, when the Calcutta Correspondent of the *Times* despatched a telegram on the subject, the temperature was the highest that had ever been registered. Professional business was almost entirely suspended, and trading operations were greatly hampered. Many persons had suffered from heat-apoplexy and sunstroke, some cases having terminated fatally.

A *conversazione* was given yesterday evening by the President and Fellows of the Royal College of Physicians, at the College. The President of the Society of Telegraph-Engineers and Electricians, and Mrs. Graves, have issued invitations for a *conversazione* in the galleries of the Royal Institute of Painters in Water Colours on Tuesday, July 10.

A REMARKABLE new series of compounds of silicon tetrafluoride with organic derivatives of ammonia have been prepared by Messrs. Comey and Loring Jackson, of Harvard. Many years ago, Gay Lussac and Thénard discovered that silicon tetrafluoride formed with gaseous ammonia a singular compound, $2NH_3.SiF_4$; this substance, which is comparatively stable in air and distinctly crystalline, is decomposed by water with formation of ammonium fluoride and silicofluoride and deposition of silicic acid. The American chemists now show that a very large number of substituted ammonias form similar compounds, and give an interesting description of the methods by which they have isolated the most important members of the series. Aniline forms two such compounds, the most stable being represented by the formula $3C_6H_5NH_2.2SiF_4$, and the other $2C_6H_5NH_2.SiF_4$, corresponding to the well-known compound with ammonia itself. The first was obtained by passing gaseous tetrafluoride of silicon over aniline, the gas delivery tube not quite touching the surface of the aniline so as to avoid the stoppage of the passage by the solid product. The combination is so rapid that practically all the fluoride is absorbed, considerable heat being evolved during the process; and, which is very satisfactory, the reaction is one of the few quantitative ones, the whole of the aniline being eventually converted into a loose white crystalline solid, which sublimes about 200° C. without fusion. This new substance is further remarkable by being insoluble in the usual organic solvents, alcohol alone slowly acting upon it with decomposition. Brought in contact with water it is at once decomposed with deposition of silicic acid; the solution, on evaporation, yielding beautiful pearly tabular crystals of aniline fluosilicate, aniline fluoride remaining dissolved. When aniline vapour was conducted into a receiver filled with silicon tetrafluoride the second compound was formed as a white powder, decomposing when warmed or when treated with water and even spontaneously on keeping. From the fact that the products of spontaneous decomposition are the first compound and free aniline, it is very probable that the true formula is $4C_6H_5NH_2.2SiF_4$, double the empirical formula; and it is evidently more than a mere coincidence that the values obtained by Mixter for the vapour density of the ammonia compound also point to the fact that its real composition is $4NH_3.2SiF_4$.

A SEVERE shock of earthquake was felt in the Hernö, an island in the Baltic, on June 7, at 7.24 a.m. Houses shook, and furniture moved. The shock went in a direction north-north-west. At the Lungö Lighthouse the shock was felt at 9.50, and was accompanied by a detonation like that of heavy artillery. Here the shock went in a direction north-east to south-west. The shock was also felt in the town of Hernösand.

A SPECIAL Committee, under Prof. Mushketoff, appointed to inquire into the causes of the earthquake which nearly destroyed Vyernyi, in Russian Turkistan, on June 9, 1887, has delivered its report to the Russian Geographical Society. The Committee, which consisted of four mining engineers and several topographers, began its work in August with a systematic exploration of the crevices in the buildings and the soil, both at Vyernyi and in the surrounding region as far as Lake Balkhash, Kulja, Lake Issyk-kul, and Tashkent. Detailed maps were made, and numerous photographs taken of the destroyed buildings. The chief shock of earthquake took place at 4h. 35m. a.m. on June 9; it destroyed nearly all the stone buildings of Vyernyi. It was followed at 4h. 45m. by another severe shock. Severe shocks continued for nearly half an hour, at intervals of one minute, and they were succeeded by feebler shocks which were felt throughout the day. Nearly 1500 stone houses were destroyed, while scarcely any harm was done to houses made of wood. Of a population of 30,000, no fewer than 332 persons were killed. The shocks continued almost every day throughout the months of June, July, and August; since September they have not been so frequent, but they go on still, and on March 4, 1888, there was a rather severe shock. The total number of shocks noticed (without instruments) reaches more than 200. It appears that the wave of earthquake had its origin in the south of Vyernyi, in the Alatau Mountains; and in the spur of mountains which separates the Kaskelen and the Berezovaya Rivers, the Expedition discovered at a height of from 5000 to 6000 feet a region where a dislocation of the rocks had taken place on an immense scale. The granitic and porphyritic rocks were dislocated and covered the slopes with masses of fresh *débris*. As to the softer deposits—clays and so on—which were still more softened by the very severe showers which preceded the earthquake, they were flowing and gliding like glaciers on the slopes of the mountains. One of these masses, on the Aksai River, has a volume of no less than 10,000,000 cubic metres. The centre of the earthquake was at a depth of from 5000 to 8000 metres, and its projection on the surface of the earth of the most severely affected regions covers a surface about twenty-three miles long and three miles wide on the northern slope of the Alatau. The earthquake spread with greater force towards the north than to the south; thus the region of the greatest destruction extends for about twenty-five miles northwards, and for only ten or thirteen miles southwards; but the whole region where the earthquake was felt has a length of nearly 1000 miles from south-west to north-east, and about 600 miles from south-east to north-west. As to its cause, it obviously must be searched for in the interior movements of the rocks—not in volcanic agencies. Regular seismological stations in Turkistan and the Caucasus will probably be the immediate outcome of the work of the Committee.

IN the *American Meteorological Journal* for May, Mr. Bôcher contributes an article on the labours of Dove, Redfield, and Espy, the greater part of whose work was included between the years 1830 and 1860. Redfield's first paper on the theory of storms was published in 1831, and was due to the fact of his having previously noticed, during a journey after a storm, that the trees were lying in opposite directions to those near his home. Espy supposed that the wind always blows inwards from the edge of the storm to a central point or line. He was a persistent opponent of Redfield. Dove's work on the theory of storms was essentially the same as Redfield's, but he also deals with the subject of winds in general. In a second article Mr. Rotch gives the description and history of the Sonnblick Mountain Observatory in Austria, and some of the preliminary results obtained. Mr. W. Upton contributes, on the part of the New England Meteorological Society, a very able paper on the remarkable storm which visited the eastern portion of the United States from the 11th to 14th of March last, and which is known as the New York "blizzard." Its peculiar characteristics were (1) the rapidity with which its energy was developed; (2) the excessive precipitation which accompanied it, principally as snow. West of the 72nd meridian it was almost wholly snow, piled up in immense drifts, making it absolutely impossible to measure it. East of this meridian it was snow and rain mixed. In a table giving the ratio of unmelted and melted snow it is shown that the density varied greatly, and furnishes proof that the method of assuming that 1·0 inch of snow equals 0·1 inch of rain is exceedingly erroneous. (3) The relatively small area of its maximum intensity. This storm was one of the most notable in this century over the Atlantic, and its behaviour over the ocean will be the subject of a special investigation by the United States Hydrographic Office.

THE Pilot Chart of the North Atlantic Ocean for the month of June shows that seven pronounced cyclonic storms passed over portions of the North Atlantic during May, but none appear to have traversed the entire ocean. Ice has been reported in increased quantity west of the 46th meridian, and, although confined for the most part to the coast of Newfoundland, it has been met with as far south as latitude 41°, in longitude 46° W. There has been a marked increase of fog over the Grand Banks and off the American coast north of Hatteras, while the amount encountered east of the 40th meridian has been unusually large. It is attributed almost entirely to the prevalence of southerly winds in that part of the ocean. During the past six months 51 vessels are known to have met with disaster in the North Atlantic ocean; the general drift of the logs of the great raft has been about east by south, and most of them are now about west-south-west from the Azores. Very few, if any, have drifted north of the 40th parallel. On April 10, latitude 41° 59'

N., longitude 47° 30′ W., Capt. McKay, of the s.s. *Pavonia*, saw a large waterspout travelling north-east at about 30 miles an hour. The great column of water reached up to a dense black, low-lying cloud, and was in shape like a huge hour-glass. It was accompanied by a terrific roaring. The spout broke, with a thunder and hail storm. Many pieces of ice, 4 to 6 inches in diameter, fell on board the ship. On the next day three distinct spouts were seen by another ship, about 250 miles north-east of the above position. These spouts gradually merged into one, and travelled out of sight.

FISHERMEN report that early on the morning of June 13 a waterspout was seen in the Grosses Haff, off Stettin. About 11.45 another one appeared near Dammausch. A steamer was, at the time, only 100 yards distant, and had to reverse her engines in order to escape it. Each lasted about a quarter of an hour.

SIR TERENCE O'BRIEN, Governor of Heligoland, in his report on the condition of that colony during the past year, states that at his instigation the Council of the Meteorological Department agreed to start a station there, and the Secretary, Mr. Scott, having gone over to superintend the putting up of the instruments, the observatory was established in August last, and will, he hopes, not only be of benefit to this branch of science, but will enable more accurate data than were formerly obtainable from the old and imperfect instruments at their disposal to be forthcoming in future Blue-book statistics.

IN a recording rain-gauge, recently devised by M. Brassard, the water passes from the bottom of the receiver into a centrally-pivoted trough, having each arm slightly depressed in the middle. It fills the two divisions alternately: the filled arm goes down, and empties itself into a lower trough, and the rocking thus caused is registered by an ordinary counter. Each rocking of the trough indicates one-tenth of a millimetre of water having fallen into the receiver. The instrument is designed to eliminate the error usually arising from evaporation.

ADVICES from the fishing village of Kerschkaranza, in the Kola Peninsula, on the White Sea, state that on January 5 a curious and destructive phenomenon occurred there. At 4 a.m. the inhabitants were awakened by a peculiar, dull, heavy detonation like that of distant artillery. Piled up to a height of several hundred feet, the ice—in consequence, no doubt, of the enormous pressure of the ocean ice without—was seen to begin moving from the north-west towards the shore. The gigantic ice wall moved irresistibly forward, and soon reached the shore and the village, which it completely buried, the ice extending a mile inland. The forward movement of the ice lasted four hours. No lives were lost.

ON April 29, when off the Westman Islands, Iceland, the captain of the Danish mail-steamer *Laura* threw overboard a letter written in Danish. On May 6 the letter was found in the stomach of a cod caught by a French fisherman off Reykjanæs, about 120 miles distant. The man showed it to the French Consul at Reykjavik, who submitted it to the captain of the *Laura*. It was much decomposed, but still readable.

A LANCE, an axe, a sword—all of bronze—an urn, a couple of whetstones, and some human remains have been found in a mound at Ogue, on the south-west coast of Norway.

AT the last meeting of the Asiatic Society of Japan, Dr. Knott read a biographical note on Ino Chukei, the great Japanese surveyor and cartographer. The following summary is taken from the report of the *Japan Weekly Mail*:—Ino was born in 1744, but did not begin his scientific career till he was fifty years of age. Up to that time he was a successful brewer. Towards the close of the century he went to Yedo, and there studied astronomy under the elder and younger Takahashi. The latter is the man who was put on his trial in 1830 for having exchanged maps of Yesso and Japan with Von Siebold for some books; the case, however, was never concluded, for he died in the meantime. In the year 1800, Ino began his work of surveying the coasts and islands of Japan, and for eighteen years he continued to labour at it, making in that time innumerable measurements of distance, and between 1100 and 1200 direct measurements of latitude. The wonder is that he did so much with such rude instruments as he had, which resembled those in use in the West in the sixteenth and seventeenth centuries. The records of his survey were compiled in 1821, and were published, under the authority of the Tokio University, in book form in 1870. In fact, the charts he constructed have been the basis of all maps that have since been made. About six or seven years ago, Ino was raised by Imperial decree to the rank of "Posthumous," or Senior Fourth Class, an honour seldom held in his time by any but nobles, and, moreover, posthumous honours are very rarely given. Ino might be named the Japanese Picard; the French astronomer who made the first good calculation of the size of the earth. The instruments—an azimuth circle and a quadrant—used by Ino in his survey were destroyed by fire, but exact copies of them, constructed in 1828, were exhibited at the meeting.

ACCORDING to the report of the Inspector of Schools in Hong Kong for the past year, the total number of schools subject to Government supervision was 94, as against 45 in 1877 and 13 in 1867; the numbers of scholars for the corresponding years being respectively 5974, 3144, and 700. Of the 5974 pupils who attended schools under Government supervision in 1887, 4160 attended missionary schools, and 1814 the Government undenominational establishments. In the colony there are five classes of schools: (1) Chinese, where a purely Chinese education is given; (2) Romanized Chinese, in which a European education is given in the Chinese language; (3) Portuguese, where a European education is given in the Portuguese language only; (4) Anglo-Chinese schools, numbering eight, with 1160 scholars; (5) English schools, numbering six, with 688 scholars, in which the children are taught in the English language only. The Government Central School presented 384 boys for the annual examination, and of these 375 passed—that is, the very high percentage of 97·65. At this latter school the subjects taught are: reading, dictation, arithmetic, Chinese into English, English into Chinese, grammar, geography, map-drawing, composition, Euclid, algebra, mensuration, history, and Latin.

MESSRS. EYRE AND SPOTTISWOODE, as the Government publishers, have issued two new volumes of the "Report on the Scientific Results of the Voyage of the *Challenger*": vol. xxiv. Zoology (2 parts, text and plates), Report on the Crustacea Macrura; vol. xxv. Zoology, Report on the Tetractinellida.

A PAPER on "Wasted Sunbeams," by Dr. G. M. Smith, of New York, has just been reprinted from the *Medical Record*. The author's aim is to show that great advantages to health might be secured by a rearrangement of the upper stories of private dwellings. "Cannot architectural ingenuity," he asks, "coached by sanitary science, contrive some method of using the thousands of acres of housetops, so that roofs, now so useful in affording indoor protection from cold, sleet, and rain, can be made additionally useful, at certain seasons, by affording outdoor recreation and protection from invalidism? Cannot the same skill contrive new designs for the upper and most salutary stories of our dwellings; playing-rooms and sunning-rooms, especially adapted for the winter season, but so cleverly fashioned that too intense torrid beams can be excluded in summer?"

MR. J. ELLARD GORE has in the press a volume entitled "Planetary and Stellar Studies: papers on the Planets, Stars, and Nebulæ." It will be published shortly by Messrs. Roper and Drowley.

THE Fifteenth Annual Report of the progress of the Geological and Natural History Survey of Minnesota, by Mr. N. H. Winchell, State Geologist, has been issued. This Report relates chiefly to the geology of the iron-bearing rocks. It seems that during the last two years great interest has been manifested with regard to the iron industry in Northern Minnesota.

WE have received Part 3 of the twenty-first volume of the Journal and Proceedings of the Royal Society of New South Wales. Among the contents are papers on Port Jackson silt beds, by F. B. Gipps; some New South Wales tan-substances, parts 3 and 4, by J. H. Maiden, Curator of the Technological Museum, Sydney; soils and subsoils of Sydney and suburbs, by J. B. Henson; quarantine and small-pox, by J. Ashburton Thompson; on the presence of fusel-oil in beer, by W. M. Hamlet; autographic instruments used in the development of flying-machines, by Lawrence Hargrave.

PART 1 of the seventh volume of the "Encyclopædic Dictionary" (Cassell and Co.) has just been issued. This carefully-compiled work, as we have repeatedly had occasion to note, contains all the words in the English language, with a full account of their origin, meaning, pronunciation, and use. Great pains are taken to secure that scientific terms shall be properly explained.

MESSRS. OLIVER AND BOYD are about to publish "India in 1887, as seen by Robert Wallace, Professor of Agriculture and Rural Economy in the University of Edinburgh." The author was four months in India and Ceylon, and made inquiry as to the breeds of cattle and horses, and as to the condition of native agriculture, soils, irrigation, &c. The work contains 290 illustrations. Prof. Wallace especially wished to "learn in an unmistakable manner what fruits the Cirencester College training had borne."

WE have received Parts 1 and 2 of "The Speaking Parrots," by Dr. Karl Russ (Upcott Gill). Much useful information is given as to the purchase and reception of parrots, the cages in which they ought to be kept, their food, the best way of taming and training them, the preservation of their health, and as to their diseases.

AN Australian edition of Longmans' "School Geography," by Mr. George G. Chisholm, has just been issued. For this edition the sections on Australasia and the British Isles have been entirely re-written, and modifications have been made in other parts of the text with the view of calling attention to matters of special interest in Australia and New Zealand.

A NEW catalogue of mathematical works has been issued by Messrs. Dulau and Co.

THE current number of the *Technology Quarterly* opens with an interesting paper, by Mr. James P. Munroe, on the beginning of the Massachusetts Institute of Technology. The Institute was legally established on April 10, 1861, after more than two years of almost constant effort in the face of opposition and discouragement.

IT has been decided that the Miss Williams Scholarship for Women, of the annual value of £20, tenable for three years, shall be offered at the entrance scholarship examination at University College, Cardiff, on September 18, and that it may be held with a College exhibition. As it is specially intended to encourage the higher education of women in Wales, preference will be given to the children of Welsh parents.

A COLLECTION of American pottery for the American National Museum is about to be made by Dr. David T. Day of the United States Geological Survey. *Science* says that the collection of Sèvres pottery presented by the French Government is an exceedingly fine one, as is also that of Japanese ceramics; and the department of Indian pottery is not approached elsewhere in the world. But the Museum possesses very little modern American pottery.

THE additions to the Zoological Society's Gardens during the past week include a Macaque Monkey (*Macacus cynomolgus*) from India, presented by Mr. A. B. Parker; a Larger Hill-Mynah (*Gracula intermedia*) from North India, presented by Mrs. M. von Kornatzki; two Naked-footed Owlets (*Athene noctua*) from France, presented by Miss Pierce; a Swainson's Lorikeet (*Trichoglossus novæ-hollandiæ*) from Australia, presented by Mr. H. A. Hankey; two Loggerhead Ducks (*Tachyeres cinereus*) from the Falkland Islands, presented by Mr. Archibald McCall; a Duyker-bok (*Cephalophus mergens* ♀) from South Africa, a Red-legged Partridge (*Caccabis rufa*), a Barbary Partridge (*Caccabis petrosa*), five —— Pigeons (*Columba ballii*) from Teneriffe, deposited; a Bennett's Wallaby (*Halmaturus bennetti* ♀), two Long-fronted Gerbilles (*Gerbillus longifrons*) born in the Gardens; a Yellow-legged Herring Gull (*Larus cachinnans*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

ROTATION PERIOD OF THE SUN FROM FACULÆ.—The fifth part of vol. iv. of the Publications of the Astrophysical Observatory at Potsdam has recently appeared, and contains a determination by Dr. J. Wilsing of the rotation period of the sun from observations of faculæ. The previous determinations of the solar rotation have been based upon observations of the spots, or upon the relative displacement of lines in the spectra of the east and west limbs, for, as faculæ can usually only be seen well when near the limb, and therefore can seldom be watched for more than three consecutive days, and as they often undergo rapid changes, they did not seem well suited for such a discussion. Their irregular and often straggling shapes, too, render measures of their positions much less precise than those of spots. Notwithstanding these difficulties Dr. Wilsing's inquiry seems to have met with a measure of success. Of the faculæ shown on the solar photographs taken at Potsdam from 1884 March 14 to August 31, 144 groups were seen at three or more different epochs, at intervals of one or more semi-rotations. Arranging these according to their distribution in solar latitude, in zones of 3° wide, Dr. Wilsing finds practically the same rotation period for each zone from $+24°$ to $-33°$, the difference from the mean of the daily angular motion only exceeding 2′ in a single instance, and in many cases amounting only to 20″ or 30″. As these differences are so small and follow no law, it would appear that, whilst, as Carrington and Spoerer have shown, the different spot zones have different rates of rotation, the layer of the faculæ rotates as a whole. Since the faculæ are certainly at a higher level than the spots, this conclusion is one which will fail to be accepted until we have much further and more convincing evidence than we have at present. In the present discussion it sometimes happens that a group of faculæ is considered as identical with an earlier group seen two or three semi-rotations earlier, when the same part of the sun has been seen in the interval, but without showing the group, although the district has been favourably presented for displaying faculæ. In such a case, and particularly if several semi-rotations have elapsed, the two groups will be identified or not according to the rotation period assumed; so that if a single rotation period for the whole sun be assumed in the preliminary reductions of position for the sake of identification of the groups, there will be an inevitable tendency towards a single rotation period in the final result.

The mean daily angular velocity given by the faculæ is 14° 16′ 11″·3, corresponding to a sidereal period of 25d. 5h. 28m. 12s., the values for the northern and southern hemisphere, taken separately, differing only by 11″·5. It is worthy of note that this corresponds to the rotation period of spots about latitude 10°, as given alike by Carrington and Spoerer's formulæ, and that the two zones 5° to 15° yield the greater number both of spots and faculæ which are available for these investigations. The present discussion, with whatever reserve its conclusions are to be accepted, is, however, both interesting and important and should lead to further inquiries in the same direction, when a more extended series of observations should be laid under contribution.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1888 *JULY* 1–7.

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

At Greenwich on July 1

Sun rises, 3h. 50m.; souths, 12h. 3m. 38·5s.; sets, 20h. 17m.: right asc. on meridian, 6h. 43·5m.; decl. 23° 4′ N. Sidereal Time at Sunset, 14h. 58m.

Moon (at Last Quarter July 1, 4h.) rises, 0h. 8m.; souths, 6h. 9m.; sets, 12h. 22m.: right asc. on meridian, 0h. 47·5m.; decl. 0° 16′ S.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. and declination on meridian. h. m.	° ′
Mercury..	5 9	12 51	20 33	7 31·5	18 16 N.
Venus ...	3 33	11 51	20 9	6 31·2	23 41 N.
Mars ...	13 16	18 35	23 54	13 15·9	8 46 S.
Jupiter ...	16 35	20 59	1 23*	15 40·5	18 42 S.
Saturn ...	6 6	13 55	21 44	8 34·7	19 22 N.
Uranus ...	12 29	18 9	23 49	12 49·5	4 36 S.
Neptune..	1 32	9 18	17 4	3 57·8	18 49 N.

* Indicates that the setting is that of the following morning.

Comet Sawerthal.

July.	h.	Right Ascension. h. m.	Declination. ° ′
1	0	1 1·0	47 51 N.
5	0	1 3·6	48 44

July.	h.	
3	17	Sun at greatest distance from the Earth.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′			h. m.	
U Cephei	0 52·4	81 16 N.	July	5,	22 12	*m*
R Sculptoris	1 21·8	33 7 S.	,,	4,		*M*
V Tauri	4 45·6	17 21 N.	,,	2,		*M*
T Cancri	8 50·3	20 17 N.	,,	6,		*m*
R Leonis Minoris	9 38·9	35 2 N.	,,	3,		*M*
W Virginis	13 20·3	2 48 S.	,,	7,	21 0	*M*
δ Libræ	14 55·0	8 4 S.	,,	6,	1 36	*m*
U Coronæ	15 13·6	32 3 N.	,,	2,	2 18	*m*
R Ursæ Minoris	16 31·5	72 30 N.	,,	7,		*m*
U Ophiuchi	17 10·9	1 20 N.	,,	3,	23 46	*m*
U Sagittarii	18 25·3	19 12 S.	,,	3,	1 0	*M*
β Lyræ	18 46·0	33 14 N.	,,	2,	3 0	*M*
R Lyræ	18 51·9	43 48 N.	,,	3,		*M*
η Aquilæ	19 46·8	0 43 N.	,,	2,	1 0	*m*
S Sagittæ	19 50·9	16 20 N.	,,	6,	1 0	*m*
S Cygni	20 3·2	57 40 N.	,,	1,		*M*
X Cygni	20 39·0	35 11 N.	,,	6,	23 0	*m*
T Vulpeculæ	20 46·7	27 50 N.	,,	2,	1 0	*M*
			,,	3,	2 0	*m*
δ Cephei	22 25·0	57 51 N.	,,	7,	0 0	*m*
R Cassiopeiæ	23 52·7	50 46 N.	,,	7,		*M*

M signifies maximum; *m* minimum.

GEOGRAPHICAL NOTES.

AT Monday's meeting of the Royal Geographical Society, Lieutenant Wissmann was present, and was formally presented by the President with the gold medal which has been awarded to him by the Society for his exploring work in Africa. Lieutenant Wissmann afterwards gave some account of his explorations in the region to the south of the great Congo bend. He began his African work eight years ago in company with the late Dr. Pogge, with whom he traversed the region lying between Loanda and Nyangwe on the Upper Congo. The Kassai and several others of the great rivers that flow north to the Congo were crossed, and a large area of new country, thickly covered with an interesting population, opened up. Dr. Pogge returned to the west coast, whilst Lieutenant Wissmann proceeded from Nyangwe to Zanzibar. He returned to Africa a second time in the service of the King of the Belgians, and in company with Dr. Wolf, Lieutenant von François, and others, made his way again from Loanda into the interior. During the period between 1884 and 1887, Lieutenant Wissmann explored the Great Kassai, and did much to unravel the complicated system of rivers, of which it is the centre. Moreover, his observations on the people, as well as the fauna and flora, render his work of great scientific value. He again crossed to Nyangwe, and, by Lakes Tanganyika and Nyassa, reached the east coast at the mouth of the Zambesi. He returned to Europe in the autumn of last year, with his health shattered, and was compelled to go to Madeira to recruit. Now Lieutenant Wissmann returns to Germany, and will no doubt there work out the results of his eight years' work in Africa. Already one volume has been published, dealing with the exploration of the Kassai-Sankuni.

CAPTAIN W. J. L. WHARTON, the Hydrographer, also read a paper at Monday's meeting of the Royal Geographical Society. He described the results of a very complete examination which has recently been made of Christmas Island, in the Indian Ocean, some 200 miles south of the western end of Java. The island is a peculiar one, and extremely difficult to explore. It consists apparently of high cliffs of coral, covered with the densest vegetation. After describing the results of examination by Captain Aldrich and others, Captain Wharton concluded by giving a summary of the conclusions to be drawn. We have, he said, a high island, on the surface of which, wherever examined, we find limestone, bearing in most places the appearance of coral origin, though in some specimens the shells of the Foraminifera abound, and in none of them have direct evidences of coral structure been detected. It must be remembered, however, that coral limestone becomes so altered by the deposition of lime by infiltration, that a large surface of it may be searched before a piece retaining its coralline structure is found, and that the specimens sent home are very small. From the description of Captain Aldrich, who is well acquainted with coral formations, it may be taken for granted that the majority of this rock is of coral origin. The rock forming the summit is of this structureless character. In two spots, and at the bottom of a hole in the summit of the ridge, we have volcanic rock. The island is very steep on all sides, great depths being found close to the cliffs, while on all sides, at a short distance, soundings over three miles in depth were obtained. It appears, then, most probable that Christmas Island is founded on a volcanic mound which rose from the bottom to a certain distance from the surface of the sea; that Foraminifera shells dying on the surface were rained upon it in sufficient number to form a stratum, since solidified into limestone rock; that as the mound neared the surface, corals built upon it, and it is possible from the sketch of the island, and from Captain Aldrich's description of the slope of the ridge inwards, that it first assumed an atoll form. This, however, is a mere inference from probabilities. The island was next gradually upheaved, the coral growing outwards on the gentle slope until a period of immobility ensued long enough to permit the waves to erode the upper cliff. Another short period of upheaval, and one of stationary character ensued, when the second cliff was worn away. A third interval of upheaval, probably longer than the others, and then a second stand, when the lowest and highest inland cliff was formed. Finally, another lift was given, and the stationary period now in existence completed the process. The volcanic stones found in various places on the higher parts of the island point to a thinning of the limestone covering in those places. Denudation has worn away the limestone, and the volcanic core is consequently exposed. Man has never lived on Christmas Island, nor would it be a pleasant residence, as, apart from the fact that there is no water—the rain sinking into the limestone rock—the extreme discomfort of locomotion, and the absence of any harbour whence the produce that might possibly be raised could be conveniently shipped, will deter any settlers from seeking a home there until other more favourable spots are occupied. There is no other instance with which Captain Wharton is acquainted of an island of this height retaining its coral covering so intact. Coral reefs have been found at heights of 1000 feet in Cuba, in the Fiji Islands, and other places; but in all cases they are mere fragments, and the intervening spaces show no signs of coral. Further and closer investigation may record more direct evidence of its structure, and of the successive steps which have resulted in its present condition; but the Hydrographer thought our present knowledge of Christmas Island was sufficient to make this short notice interesting to the Society.

DIFFRACTION OF SOUND.[1]

THE interest of the subject which I propose to bring before you this evening turns principally upon the connection or analogy between light and sound. It has been known for a very long time that sound is a vibration; and everyone here knows that light is a vibration also. The last piece of knowledge, however, was not arrived at so easily as the first; and one of the difficulties which retarded the acceptance of the view that light is a vibration was that in some respects the analogy between light and sound seemed to be less perfect than it should be. At the present time many of the students at our schools and universities can tell glibly all about it; yet this difficulty is one not to be despised, for it exercised a determining influence over the great mind of Newton. Newton, it would seem, definitely rejected the wave-theory of light on the ground that according to such a theory light would turn round the corners of obstacles, and so abolish shadows, in the way that sound is generally supposed to do. The fact that this difficulty seemed to Newton to be insuperable is, from the point of view of the advancement of science, very encouraging. The difficulty which stopped Newton two centuries ago is no difficulty now. It is well known that the question depends upon the relative wave-lengths in the two cases. Light-shadows are sharp under ordinary circumstances, because the wave-length of light is so small; sound-shadows are usually of a diffused character, because the wave-length of sound is so great. The gap between the two is enormous. I need hardly remind you that the wave-length of C in the middle of the musical scale is about 4 feet. The wave-length of the light with which we are usually concerned, the light towards the middle of the spectrum, is about the forty-thousandth of an inch. The result is that an obstacle which is immensely large for light may be very small for sound, and will therefore behave in a different manner.

That light-shadows are sharp is a familiar fact, but as I can prove it in a moment I will do so. We have here light from the electric arc thrown on the screen; and if I hold up my hand thus we have a sharp shadow at any moderate distance, which shadow can be made sharper still by diminishing the source of light. Sound-shadows, as I have said, are not often sharp; but I believe that they are sharper than is usually supposed, the reason being that when we pass into a sound-shadow—when, for example, we pass into the shade of a large obstacle, such as a building—it requires some little time to effect the transition, and the consequence is that we cannot make a very ready comparison between the intensity of the sound before we enter and its diminution afterwards. When the comparison is made under more favourable conditions, the result is often better than would have been expected. It is, of course, impossible to perform experiments with such obstacles before an audience, and the shadows which I propose to show you to-night are on a much smaller scale. I shall take advantage of the sensitiveness of a flame such as Professor Tyndall has often used here—a flame sensitive to the waves produced by notes so exceedingly high as to be inaudible to the human ear. In fact, all the sounds with which I shall deal to-night will be inaudible to the audience. I hope that no quibbler will object that they are therefore not sounds: they are in every respect analogous to the vibrations which produce the ordinary sensations of hearing.

I will now start the sensitive flame. We must adjust it to a reasonable degree of sensitiveness. I need scarcely explain the mechanism of these flames, which you know are fed from a special gas-holder supplying gas at a high pressure. When the pressure is too high, the flame flares on its own account (as this one is doing now), independently of external sound. When the pressure is somewhat diminished, but not too much so—when the flame "stands on the brink of the precipice" were, I think, Tyndall's words—the sound pushes it over, and causes it to flare; whereas, in the absence of such sound, it would remain erect and unaffected. Now, I believe, the flame is flaring under the action of a very high note that I am producing here. That can be tested in a moment by stopping the sound, and seeing whether the flame recovers or not. It recovers now. What I want to show you, however, is that the sound-shadows may be very sharp. I will put my hand between the flame and the source of sound, and you will see the difference. The flame is at present flaring; if I put my hand here, the flame recovers. When the adjustment is correct, my hand is a sufficient obstacle to throw a most conspicuous shadow. The flame is now in the shadow of my hand, and it recovers its steadiness: I move my hand up, the sound comes to the flame again, and it flares. When the conditions are at their best, a very small obstacle is sufficient to make the entire difference, and a sound-shadow may be thrown across several feet from an obstacle as small as the hand. The reason of the divergence from ordinary experience here met with is, that while the hand is a fairly large obstacle in comparison with the wave-length of the sound I am here using, it would not be a sufficiently large obstacle in comparison with the wave-lengths with which we have to do in ordinary life and in music.

Everything then turns upon the question of the wave-length. The wave-length of the sound that I am using now is about half an inch. That is its complete length, and it corresponds to a note that would be very high indeed on the musical scale. The wave-length of middle C being four feet, the C one octave above that is two feet; two octaves above, one foot; three octaves above, six inches; four octaves, three inches; five octaves, one and a half inch; six octaves, three-quarters of an inch; between that and the next octave, that is to say, between six and sèven octaves above middle C, is the pitch of the note that I was just now using. There is no difficulty in determining what the wave-length is. The method depends upon the properties of what are known as stationary sonorous waves as opposed to progressive waves. If a train of progressive waves are caused to impinge upon a reflecting wall, there will be sent back or reflected in the reverse direction a second set of waves, and the co-operation of these two sets of waves produces one set or system of stationary waves; the distinction being that, whereas in the one set the places of greatest condensation are continually changing and passing through every point, in the stationary waves there are definite points for the places of greatest condensation (nodes), and others distinct and definite (loops) for the places of greatest motion. The places of greatest variation of density are the places of no motion: the places of greatest motion are places of no variation of density. By the operation of a reflector, such as this board, we obtain a system of stationary waves, in which the nodes and loops occupy given positions relatively to the board.

You will observe that as I hold the board at different distances behind, the flame rises and falls—I can hardly hold it still enough. In one position the flame rises, further off it falls again; and as I move the board back the flame passes continually from the position of the node—the place of no motion—to the loop or place of greatest motion and no variation of pressure. As I move back, the aspect of the flame changes; and all these changes are due to the reflection of the sound-waves by the reflector which I am holding. The flame alternately ducks and rises, its behaviour depending npon the different action of the nodes and loops. The nodes occur at distances from the reflecting wall, which are even multiples of the quarter of a wave-length; the loops are, on the other hand, at distances from the reflector which are odd multiples, bisecting therefore the positions between the loops. I will now show you that a very slight body is capable of acting as a reflector. This is a screen of tissue-paper, and the effect will be apparent when it is held behind the flame and the distances are caused to vary. The flame goes up and down, showing that a considerable proportion of the sonorous intensity incident upon the paper screen is reflected back upon the flame; otherwise the exact position of the reflector would be of no moment. I have here, however, a different sort of reflector. This is a glass plate —I use glass so that those behind may see through it—and it will slide upon a stand here arranged for it. When put in this position the flame is very little affected: the place is what I call a node—a place where there is great pressure variation, but no vibratory velocity. If I move the glass back, the flame becomes vigorously excited: that position is a loop. Move it back still more, and the flame becomes fairly quiet; but you see that as the plate travels gradually along, the flame goes through these evolutions as it occupies in succession the position of a node or the position of a loop. The interest of this experiment for our present purpose depends upon this—that the distances through which the glass plate, acting as a reflector, must be successively moved in order to pass the flame from a loop to the next loop, or from a node to the consecutive node, is in each case half the wave-length; so that by measuring the space through which the plate is thus withdrawn one has at once a measurement of the wave-length, and consequently of the pitch of the sound, though one cannot hear it.

[1] Lecture delivered by Lord Rayleigh, F.R.S., at the Royal Institution, on January 20, 1888.

The question of whether the flame is excited at the nodes or at the loops—whether at the places where the pressure varies most, or at those where there is no variation of pressure, but considerable motion of air—is one of considerable interest from the point of view of the theory of these flames. The experiment could be made well enough with such a source of sound as I am now using; but it is made rather better by using sounds of a lower pitch, and therefore of greater wave-length, the discrimination being then more easy. Here is a table of the distances which the screen must be from the flame in order to give the maximum and the minimum effect, the minimum being practically nothing at all.

Table of Maxima and Minima.

Max.	Min.
1·1	
	3·0
4·5	
	5·9
7·5	
	8·9
10·3	
	11·7
13·0	
	14·7
15·9	

The distance between successive maxima or successive minima is very nearly 3 cm., and this is accordingly half the length of the wave.

But there is a further question behind. Is it at the loops or is it at the nodes that the flame is most excited? The table shows what the answer must be, because the nodes occur at distances from the screen which are even multiples, and the loops at distances which are odd multiples; and the numbers in the table can be explained in only one way—that the flame is excited at the loops corresponding to the odd multiples, and remains quiescent at the nodes corresponding to the even multiples. This result is especially remarkable, because the ear, when substituted for the flame, behaves in the exactly opposite manner, being excited at the nodes and not at the loops. The experiment may be tried with the aid of a tube, one end of which is placed in the ear, while the other is held close to the burner. It is then found that the ear is excited the most when the flame is excited least, and *vice versâ*. The result of the experiment shows, moreover, that the manner in which the flame is disintegrated under the action of sound is not, as might be expected, symmetrical in regard to the axis of the flame. If it were symmetrical, it would be most affected by the symmetrical cause—namely, the variation of pressure. The fact being that it is most excited at the loop, where there is the greatest vibratory velocity, shows that the method of disintegration is unsymmetrical, the velocity being a directed quantity. In that respect the theory of these flames is different from the theory of the water-jets investigated by Savart, which resolve themselves into detached drops under the influence of sonorous vibration. The analogy fails at this point, and it has been pressed too far by some experimenters on the subject. Another simple proof of the correctness of the result of our experiment is that it makes all the difference which way the burner is turned in respect of the direction in which the sound-waves are impinging upon it. If the phenomenon were symmetrical, it would make no difference if the flame were turned round upon its vertical axis. But we find that it does make a difference. This is the way in which I was using the flame, and you see that it is flaring strongly. If I now turn the burner round through a right angle, the flame stops flaring. I have done nothing more than turn the burner round and the flame with it, showing that the sound-waves may impinge in one direction with great effect, and in another direction with no effect. The sensitiveness occurs again when the burner is turned through another right angle; after three right angles there is another place of no effect; and after a complete revolution of the flame the original sensitiveness recurs. So that if the flame were stationary, and the sound-waves, came, say, from the north or south, the phenomena would be exhibited; but if they came from the east or west, the flame would make no response.

This is of convenience in experimenting, because, by turning the burner round, I make the flame almost insensitive to a sound, and I am now free to show the effect of any sound that may be brought to it in the perpendicular direction. I am going to use a very small reflector—a small piece of looking-glass. Wood would do as well; but looking-glass facilitates the adjustment, because my assistant, by seeing the reflection, will be able to tell me when I am holding it in the best position. Now, the sound is being reflected from the bit of glass, and is causing the flame to flare, though the same sound, travelling a shorter distance and impinging in another direction, is incompetent to produce the result (Fig. 1).

I am now going to move the reflector to and fro along the line perpendicular to that joining the source and the burner, all the while maintaining the adjustment, so that from the position of the source of sound the image of the flame is seen in the centre of the mirror. Seen from the source, it is still as central as before, but it has lost its effect, and as I move it to and fro I produce cycles of effect and no effect. What is the cause of this? The question depends upon something different from what I have been speaking of hitherto; and the explanation is, that we are here dealing with a diffraction phenomenon. The mirror is a small one, and the sound-waves which it reflects are not big enough to act in the normal manner. We are really dealing with the same sort of phenomena as arise in optics when we use small pin-holes for the entrance of our light. It is not very easy to make the experiment in the present form quite simple, because the mirror would have to be withdrawn, all the while maintaining a somewhat complicated adjustment. In order to raise the question of diffraction in its simplest shape, we must have a direct course for the sound between its origin and the place of observation, and interpose in the path a screen perforated with such holes as we desire to try.

The screen I propose to use is of glass. It is a practically perfect obstacle for such sounds as we are dealing with; but it is perforated here with a hole (20 cm. diameter), rendered more evident to those at a distance by means of a circle of paper pasted round it. The edge of the hole corresponds to the inner circumference of the paper. We shall thus be able to try the effect of different-sized apertures, all the other circumstances remaining unchanged. The experiment is rather a difficult one before an audience, because everything turns on getting the exact adjustment of distances relatively to the wave-length. At present the sound is passing through this comparatively large hole in the glass screen, and is producing, as you see, scarcely any effect upon the flame situated opposite to its centre. But if (Fig. 2) I diminish the size of the hole by holding this circle of zinc (perforated with a hole 14 cm. in diameter) in front of it, it is seen that, although the hole is smaller, we get a far greater effect. That is a fundamental phenomenon in diffraction. Now I reopen the larger hole, and the flame becomes quiet. So that it is evident that in this case the sound produces a greater effect in passing through a small hole than in passing through a larger one. The experiment may be made in another way, by obstructing the central in place of the marginal part of the aperture in the glass. When I hold this unperforated disk of zinc (14 cm. in diameter) centrically in front, we get a greater effect than when the sound is allowed to pass through both parts of the aperture. The flame is now flaring vigorously under the action of the sonorous waves passing the marginal part of the aperture, whereas it will scarcely flare at all under the action of waves passing through both the marginal and the central hole.

This is a point which I should like to dwell upon a little, for it lies at the root of the whole matter. The principle upon which it depends is one that was first formulated by Huygens, one of the leading names in the development of the undulatory theory of light. In this diagram (Fig. 3) is represented in section the different parts of the obstacle. C represents the source of sound, B represents the flame, and A P Q is the screen. If we choose a point, P, on this screen, so that the whole distance from B to C, reckoned through P, viz. B P C, exceeds the shortest distance B A C by exactly half the wave-length of the sound, then the circular area, whose radius is A P, is the first zone. We take next another point, Q, so that the whole distance B Q C exceeds the previous one by half a wave-length. Thus we get the second zone represented by P Q. In like manner, by taking different points in succession such that the last distance taken exceeds the previous one every time by half a wave-length, we may map out the whole of the obstructing screen into a series of zones called Huygens' zones. I have here a material embodiment of that notion, in which the zones are actually cut out of a piece of zinc. It is easy to prove that the effects of the parts of the wave traversing the alternate zones are opposed; that whatever may be the effect of the first zone, A P, the exact opposite will be the effect of P Q, and so on. Thus, if A P and P Q are both allowed to operate, while all beyond Q is cut off, the waves will neutralize one another, and the effect will be immensely less than if A P or P Q operated alone. And that is what we saw just now. When I used the inner aperture only, a comparatively loud sound acted upon the flame. When I added to that inner aperture the additional aperture P Q, the sound disappeared, showing that the effect of the latter was equal and opposite to that of A P, and that the two neutralized each other.

[If A C = a, A B = b, A R = x, wave-length = λ, the value of x for the external radius of the nth zone is

$$x^2 = n\lambda \frac{a+b}{ab};$$

or, if $a = b$,

$$x^2 = \tfrac{1}{2} n\lambda a.$$

With the apertures used above, $x^2 = 49$ for $n = 1$; $x^2 = 100$ for $n = 2$; so that

$$\lambda a = 100,$$

the measurements being in centimetres. This gives the suitable distances, when λ is known. In the present case $\lambda = 1 \cdot 2$, $a = 83$.]

Closely connected with this there is another very interesting experiment, which can easily be tried, and which has also an important optical analogy. I mean the experiment of the shadow thrown by a circular disk. If a very small source of light be taken—such a source as would be produced by perforating a thin plate in the shutter of the window of a dark room with a pin, and causing the rays of the sun to enter horizontally—and if we interpose in the path of the light a small circular obstacle, and then observe the shadow thrown in the rear of that obstacle, a very remarkable peculiarity manifests itself. It is found that in the centre of the shadow of the obstacle, where the darkness might

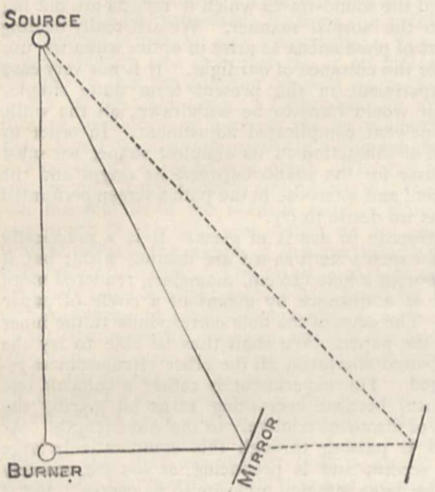


FIG. 1.

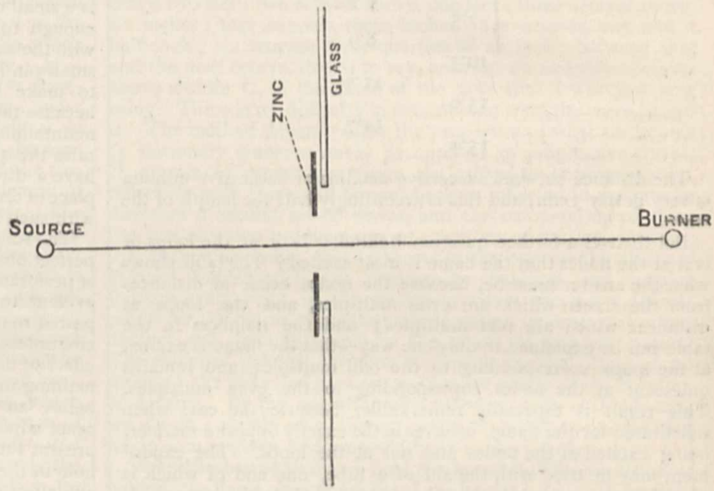


FIG. 2.

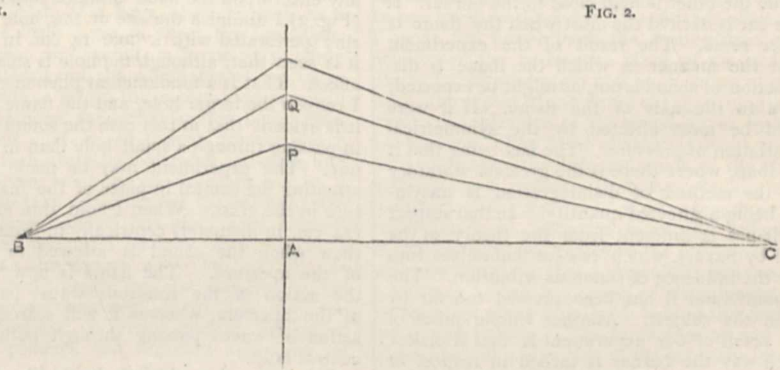


FIG. 3.

be expected to be greatest, there is, on the contrary, no darkness at all, but a bright spot, a spot as bright as if no obstacle intervened in the course of the light. The history of this subject is curious. The fact was first observed by Delisle in the early part of the eighteenth century, but the observation fell into oblivion. When Fresnel began his important investigations, his memoir on diffraction was communicated to the French Academy, and was reported on by the great mathematician Poisson. Poisson was not favourably impressed by Fresnel's theoretical views. Like most mathematicians of the day, he did not take kindly to the wave theory; and in his report on Fresnel's memoir, he made the objection that if the method were applied, as Fresnel had not then done, to investigate what should happen in the shadow of a circular obstacle, it brought out this paradoxical result, that in the centre there would be a bright point. This was regarded as a *reductio ad absurdum* of the theory. All the time, as I have mentioned, the record of Delisle's observations was in existence. The remarks of Poisson were brought to the notice of Fresnel, the experiment was tried, and the bright point was rediscovered, to the gratification of Fresnel and the confirmation of his theoretical views. I don't propose to attempt the optical experiment now, but it can easily be tried in one's own laboratory. A long room or passage must be darkened: a fourpenny bit may be used as the obstacle, strung up by three hairs attached by sealing-wax. When the shadow of the obstacle is received on a piece of ground glass, and examined from behind with a magnifying lens, the bright spot will be seen without much difficulty. But what I propose to show you is the corresponding phenomenon in the case of sound. Fresnel's reasoning is applicable, word for word, to the phenomena we are considering just as much as to that which he, or rather Poisson, had in view. The disk (Fig. 4), which I shall hang up now between the source of sound and the flame, is of glass. It is about 15 inches in diameter. I believe the flame is flaring now from being in the bright spot. If I make a small motion of the disk, I shall move the bright spot and the effect will disappear. I am pushing the disk away now, and the flaring has stopped. The flame is still in the shadow of the disk, but not at the centre. I bring the disk back again, and when the flame comes into the centre it flares again vigorously. That is the phenomenon which was discovered by Delisle and confirmed by Arago and Fresnel, but mathematically it was suggested by Poisson.

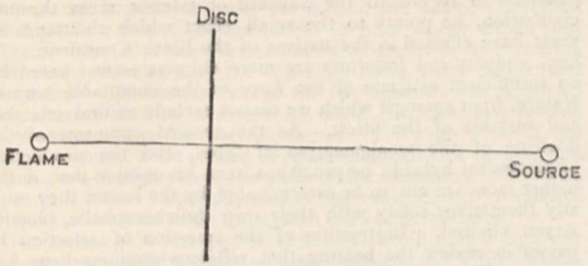


FIG. 4.

Poisson's calculation related only to the very central point in the axis of the disk. More recently the theory of this experiment has been very thoroughly examined by a German mathematician, Lommel; and I have exhibited here one of the curves given by him embodying the results of his calculations on the subject (Fig. 5).

The abscissæ, measured horizontally, represent distances drawn outwards from the centre of the shadow O; the ordinates measure the intensity of the light at the various points. The maximum intensity O A is at the centre. A little way outwards, at B, the intensity falls almost, but not quite, to zero. At C there is a revival of intensity, indicating a bright ring; and further out there is a succession of subordinate fluctuations. The curve on

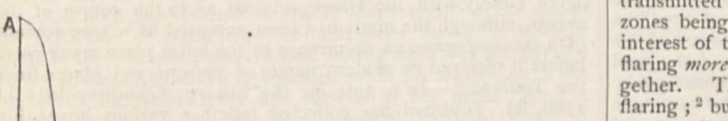


FIG. 5.

the other side of O A would of course be similar. This curve corresponds to the distances and proportions indicated. a is the distance between the source of sound and the disk; b is the distance between the disk and the flame, the place where the intensity is observed. The numbers given are taken from the notes of an experiment which went well. If we can get our flame to the right point of sensitiveness, we may succeed in bringing into view not only the central spot, but the revived sound which occurs after you have got away from the central point and have passed through the ring of silence. There is the loud central point. If I push the disk a little, we enter the ring of silence, B;[1] a little further, and the flame flares again, being now at C.

Although we have thus imitated the optical experiment, I must not leave you under the idea that we are working under the same conditions that prevail in optics. You see the diameter of my disk is 15 inches, and the length of my sound-wave is about half an inch. My disk is therefore about thirty wave-lengths in diameter, whereas the diameter of a disk representing thirty wave-lengths of light would be only about $\frac{1}{1000}$ inch. Still, the conditions are sufficiently alike to get corresponding effects, and to obtain this bright point in the centre of the shadow conspicuously developed.

I will now make an experiment illustrating still further the principle of Huygens' zones, which I have already roughly sketched. I indicated that the effect of contiguous zones was equal and opposite, so that the effect of each of the odd zones is one thing, and of the even zones the opposite thing. If we can succeed in so preparing a screen as to fit the system of zones, allowing the one set to pass, and at the same time intercepting the other set, then we shall get a great effect at the central point, because we shall have removed those parts which, if they remained, would have neutralized the remaining parts. Such a system has been cut out of zinc, and is now hanging before you. When the adjustments are correct, there will be produced, under the action of that circular grating, an effect much greater than would result if the sound-waves were allowed to pass on without any obstruction. The only point difficult of explanation is as to what happens when the system of zones is complete, and extends to infinity, viz. when there is no obstruction at all. In that case it may be proved that the aggregate effect of all the zones is, in ordinary cases, half the effect that would be produced by any one zone alone, whereas if we succeed in stopping out a number of the alternate zones, we may expect a large multiple of the effect of one zone. The grating is now in the right position, and you see the flame flaring strongly, under the action of the sound-waves transmitted through these alternate zones, the action of the other zones being stopped by the interposition of the zinc. But the interest of the experiment is principally in this, that the flame is flaring *more* than it would do if the grating were removed altogether. There is now, without the grating, a very trivial flaring;[2] but when the grating is in position again—though a great part of the sound is thereby stopped out—the effect is far more powerful than when no obstruction intervened. The grating acts, in fact, the part of a lens. It concentrates the sound upon the flame, and so produces the intense magnification of effect which we have seen.

[The exterior radius of the nth zone being x, we have, from the formula given above—

$$\frac{1}{a} + \frac{1}{b} = \frac{n\lambda}{x^2};$$

so that if a and b be the distances of the source and image from the grating, the relation required to maintain the focus is, as usual,

$$\frac{1}{a} + \frac{1}{b} = \frac{1}{f},$$

where f, the *focal length*, is given by—

$$f = \frac{x^2}{n\lambda}.$$

In the actual grating, eight zones (the first, third, fifth, &c.) are occupied by metal. The radius of the first zone, or central circle, is 3 inches, so that $x^2/n = 9$. The focal length is necessarily a function of λ. In the present case $\lambda = \frac{1}{2}$ inch nearly, and therefore $f = 18$ inches. If a and b are the same, each must be made equal to 36 inches.]

SCIENTIFIC SERIALS.

Revue d'Anthropologie, troisième série, tome iii., 1888 (Paris).—Stratigraphic palæontology in relation to man, by M. Marcellin Boule. Rejecting as unauthenticated all evidence of human existence in the Tertiary age, the author considers the

[1] With the data given above the diameter of the silent ring is two-thirds of an inch.

[2] Under the best conditions the flame is absolutely unaffected.

grounds on which we may assume that the so-called Saint Acheul flint instruments, found in alluvial beds of undoubted Quaternary origin, supply the most ancient testimony of man's presence on the surface of the earth. While attaching great importance to the careful elucidation of the chronological order in which the oldest traces of man appear relatively to the different series of the Quaternary formations, he points out the imminent risk of losing the few opportunities which still remain of studying this connection between the objects found and the nature and order of sequence of the beds in which they were deposited, owing to the most interesting finds having long been made to swell the collections of our Museums without reference to their value as exponents of the problems of our primitive history. M. Marcellin Boule considers that palæologists have erred in assuming that all beds containing the same fossil remains must necessarily belong to the same epoch, and that sufficient importance has not been attached to the fact that the same deposit often contains a mixture of animal forms belonging both to so-called northern and southern types. In explanation of these and many other anomalous phenomena, he thinks we may derive important help from a careful consideration of the intermittence and recurrence of glacial action. In regard to this point he recognizes the great value of the labours of British and American as well as Scandinavian and German geologists when compared with those of the majority of their French *confrères*; and, following the lead of our own palæontologists, he refuses to believe that any traces of human existence can be referred to pre-glacial ages, although some may perhaps be assigned to inter-glacial periods; while he considers that in certain northern lands, as Denmark and Southern Sweden, where there is a complete absence of Palæolithic objects, their non-appearance may be explained by the ice-covering not having been entirely removed in these regions till the dawn of the age of polished stone.—The tibia in the Neanderthal race, by Prof. Julien Fraipont. As a further exposition of the views which the author, in concert with M. Lohest, had expressed in regard to the effect on the maintenance of the vertical position of the obliquity and curvature of the femur in the "men of Spy," he now attempts to show, from the observations of others, and his own anatomical experiments, that in this inclination of the head of the femur we have a characteristic common to the anthropoids. An ingeniously devised series of determinations of the variations of the axis of the head of the tibia in recent man, the men of Spy, the gorilla, and other anthropoids, shows the gradual straightening of the axis as we ascend from the latter to existing man, in whom there is a well-marked tendency to the fusion of the axis of the head of the tibia with that of the body. From a careful comparison of the gradual anatomical changes presented in man since his earliest representative appeared in the Quaternary age, M. Fraipont believes we are justified in assuming that the human race has progressively acquired a more and more vertical posture.—On the population of the ancient Pagus-Cap-Sizun, "Cape du Raz," by MM. Le Carguet and P. Topinard. In considering the map of France from an ethnographic point of view, French anthropologists are generally agreed in regarding as specially Celtic the region which includes Brittany, Auvergne, and the entire mass of mountains extending through Central France and Savoy. The population of the eastern portion of this region is more brachycephalic than that of the western, which has been largely affected by admixture with the blonde, tall, dolichocephalic races whose presence is traceable everywhere in Europe, although more definitely the further north we go. This admixture of types is most strongly marked in Brittany, where French is the spoken tongue in Haute-Bretagne, and Breton (apparently a dialect derived from an ancient Kymric language) the predominant tongue in Basse-Bretagne. Among the many interesting localities of the latter region, special attention is due to Pointe du Raz, which, from the nature of its rocky boundaries on the land side, and its position further west than any other in France, has been virtually cut off from communication with the rest of the country, in consequence of which its population presents relatively fewer marks of mixed origin. M. Topinard supplies an interesting report on the geological, historical, and ethnological characteristics of the Cape du Raz district, and thus enhances the value of the series of observations regarding the population of this far west of France which have been supplied by M. Le Carguet, and may be generally summarized as leading to the inference that the "Capiste" race is essentially Breton in regard to the predominance of blue eyes with dark hair, and their generally low stature, these characteristics being associated with a disposition in which courage and energy are blended with strongly marked avarice and a love of greed; while in other respects they show evidence of a strongly-marked Celtic type.—Heredity in political economy, by M. de Lapouge. In this sequel to his former articles on "Inequality among Men," the author urges that it is the duty of the State to use all means at its disposal to eliminate the degenerate, and multiply the favoured elements of which the community is composed. As an ultra-pessimist in regard to the advance of inferior races through civilization, he points to the small effect which thousands of years have effected in the natives of the Black Continent. To him, equality and fraternity are mere delusive terms, based on an insufficient estimate of the force of the immutable laws of Nature, from amongst which we cannot exclude natural selection and survival of the fittest. As the avowed opponent of the doctrine of the amalgamation of types, and the production of permanent hybrids, he proclaims it as his opinion that, if the higher races are not to be exterminated by the lower, they must ally themselves solely with their own dolichocephalic, blonde, Aryan kindred. In treating of the question of selection he passes in review the bearing that religious opinions have had among different races in determining various degrees of consanguinity which were to be recognized as natural barriers against intermarriage among relatives. Considered generally, M. de Lapouge's article is a protest against futile attempts in the assumed name of philanthrophy to raise inferior types at the expense of those whom history from its earliest dawn has shown us to have been the leaders and pioneers in every path of human progress.—In a note on the recurrence among the Provençals of the present day of the myth of Ibicus, M. le Dr. Bérenger-Férand draws attention to the numerous characteristics derived from Hellenic antiquity which are still to be met with on the site of ancient Greek settlements. The modern tale of the detection of a murder through a reference by the murderers themselves to the birds which had been near the spot where the deed was done, is current both at Toulon and La Grasse. Both versions agree closely with the Greek original as to the course of the events, although the myth had been accepted as a true account of a contemporaneous occurrence in the latter place many years before it received its modern names of persons and places from the Toulonais.—In a note on the history of anthropology in 1788, M. Topinard has collected together various interesting details as to the precise meaning attached at that and earlier periods of the last century to the terms anthropology and ethnology. A doubt exists, however, as to the latter term, which is generally believed to have originated in its present sense with W. Edwards, when in 1839 he founded his so-called Ethnological Society. Dr. Topinard derives many curious facts from the manuscript work of Chavannes, Professor of Theology at Lausanne, whose speculative views as given in his writings he believes to have largely influenced the Encyclopædists no less than the author of "Emile."—Report by Dr. P. Topinard on the Neolithic skull, found at Feigneux (Oise) in 1887, which presents undoubted traces of having been trepanned both during life and after death.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, May 31.—"Colour Photometry. Part II. The Measurement of Reflected Colours." By Captain W. de W. Abney, R.E., F.R.S., and Major-General Festing, R.E., F.R.S.

In a previous paper we showed how the luminosity of different spectrum colours might be measured, and in the present paper we give a method of measuring the light of the spectrum reflected from coloured bodies such as pigments in terms of the light of the spectrum reflected from a white surface. To effect this the first named of us devised a modification of our previous apparatus. Nearly in contact with the collimating lens was placed a double image prism of Iceland spar, by which means two spectra were thrown on the focussing screen of the camera (which was arranged as described in the Bakerian lecture for 1886), each formed of the light which enters the slit. The light was thus identical in both spectra. The two spectra were separated by about ¼ of an inch when the adjustments were complete. A slit cut in a card was passed through this spectrum to isolate any particular portion which might be required. The rays coming from the uppermost spectrum were reflected by means of a small right-angled prism in a direction nearly at right angles to the original direction on to another right-angled prism. Both prisms were attached to the card. From this last prism the rays fell on a lens, and formed on a white screen an image of the face of the spectroscope prism in monochromatic light. The ray of the same wave-length as that reflected from the upper spectrum passed through the lower half of the slit, and falling on another lens formed another image of the face of the prism, superposed over the first image. A rod placed in front of the screen thus cast two shadows, one illuminated by monochromatic rays from the top spectrum, and the other by those from the bottom spectrum. The illumination of the two shadows was equalized by means of rotating sectors which could be closed and opened at pleasure during the time of rotation. The angle to which the sector required to be opened to establish equality of illumination of the two shadows gave the ratio of the brightness of the two spectra. When proper adjustment had been made, the relative brightness was the same throughout the entire spectrum.

To measure the intensity of any ray reflected from a pigment, a paper was coated with it and placed adjacent to a white surface, and it was so arranged that one shadow of the rod fell on the coloured surface and the other on the white surface. The illuminations were then equalized by the sectors, and the relative intensities of the two reflected rays calculated. This was repeated throughout the spectrum. Vermilion, emerald-green, French ultramarine were first measured by the above method, and then sectors of these colours prepared, which when rotated gave a gray matching a gray obtained by rotation of black and white. The luminosity curves of these three colours were then calculated and reduced proportionally to the angle that each sector occupied in the disk. The luminosity curve of the white was then reduced in a similar manner, and it was found that the sum of the luminosities of the three colours almost exactly equalled that of the white. The same measurements were gone through with pale-yellow chrome and a French blue, which formed a gray on rotation, with like results. It was further found that *the sum of the intensities* of vermilion, blue, and green varied at different parts of the spectrum, and the line joining them was not parallel to the straight line which represented white for all colours of the spectrum and which itself was parallel to the base. Since a straight line parallel to the base indicated degraded white, it followed that if the intensity of the rays of the spectrum were reduced proportionally to the height of the ordinates above a line tangential to the curved line (which represented the sum of the intensities of the three colours at the different parts of the spectrum) and were recombined, a gray should result. A method was devised of trying this, and the experiment proved that such was the case. The same plan enabled the colour of any pigment to be reproduced from the spectrum on the screen. The combination of colours to form a gray on rotation by a colour-blind person was also tried, and after the curve of luminosity of the colours had been calculated and reduced according to the amount required in the disk, it was found that the sum of the areas of the curves was approximately equal to the white necessary to be added to a black disk to form a gray of equal intensity as perceived by him. The spectrum intensity of gas-light in comparison with the electric light was also measured, and the amount of the different colours necessary to form a gray in this light was ascertained by experiment.

As before, it was found that the calculated luminosity of the colours was equal to the white which, combined with black, formed a gray of equal luminosity.

The question of the coloured light reflected from different metals was next considered, and the method of measuring it devised, as was also the method of measuring absorption spectra. The luminosity curves obtained by the old method were compared with those obtained by the present method, and so close an agreement between them was found to exist as to give a further confirmation that our former plan was accurate. A number of pigments that can be used for forming grays by rotation were measured, and the results tabulated in percentages of the spectrum of white light and on a wave-length scale.

Physical Society, June 9.—Prof. Reinold, President, in the chair.—The following papers were read:—On the analogy between dilute solutions and gases as regards Gay-Lussac's and Boyle's and Avogadro's laws, by Prof. van 't Hoff, presented by Prof. Ramsay, F.R.S. If a dilute aqueous solution of sugar (say 1 per cent.) be placed in a vessel, A (the walls of which are permeable to water, but not to sugar molecules), and immersed in a large quantity of water, B, water will pass from B to A until a certain difference of pressure exists between the inside and outside of A, that difference depending on the temperature and concentration of the solution. The pressure is called *osmotic pressure*, and the walls of A are said to be *semi-permeable*. Such a vessel may be artificially produced by depositing ferrocyanide of copper on unglazed porcelain; but many of the experiments dealt with in the paper have been made with the cells of plants, the walls of which form good *semi-permeable membranes*. At constant temperature the osmotic pressure is found to be proportional to the concentration of the solution, and for a given concentration the pressure is proportional to the absolute temperature. Similar results have been obtained with solutions of KNO_3, K_2SO_4, NaCl, &c., and Soret has found that if a solution be heated unequally at different parts, the warmer parts are less concentrated, just as in gases under similar conditions the warmer parts are more rarefied. The numerical results are in fair accordance with those deduced from the laws above stated. Theoretical proofs of the laws are given, in which reversible cycles and the second law of thermodynamics are made use of. By similar reasoning the author concludes that "under equal osmotic pressure, and at the same temperature, equal volumes of all solutions contain the same number of molecules, and moreover the same number of molecules which would be contained in a gas under the same conditions of temperature and pressure." These results are confirmed by Pfeffer's direct determinations of osmotic pressure, and Raoult's experiments on the "molecular lowering of vapour-pressure," and the "molecular depression of the freezing-point of the solvent." The latter part of the paper contains applications to chemical phenomena. Prof. Rücker regretted that the names Boyle's law and Gay-Lussac's law had been so persistently made use of in the paper, as he thought a wrong impression would be spread as to the nature of the phenomena. He also considered it probable that the proportionality observed was merely the result of the smallness of the ranges over which the experiments had been made. Mr. H. Crompton took exception to the imaginative character of the reasoning, and thought much more experimental proof was required before the results could be accepted for any but very small ranges of concentration. In answer to Prof. Reinold, Prof. Ramsay said the experimental data were not obtained by van 't Hoff himself, but were taken chiefly from Raoult's determinations.—On a method of comparing very unequal capacities, by Dr. A. H. Fison. One coating of each condenser is joined to earth, and to one end, A, of a high resistance (20,000 or 30,000 ohms), through which a current is flowing. The small condenser is charged to the P.D. existing between the ends A, B, of the resistance, and discharged into the large one. This is repeated a great number of times. If C be a point between A and B, the resistance between A and C may be varied until the P.D. between them is equal to that between the coatings of the condensers after n operations. If the insulated coatings be now joined to C through a galvanometer, no deflection will result. The relation between the capacities C_1 and C_2 of the large and small condensers is given by

$$\left(1 + \frac{C_2}{C_1}\right)^n = \frac{R_{AB}}{R_{BC}},$$

where R_{AB}, R_{BC} are the resistances between AB and BC respectively. Since time is required to perform the operation, the instantaneous capacities cannot be compared, and accordingly the measurements are taken after a definite time of electrification. A special rotating key was shown for performing ten operations per revolution, in which a trigger arrangement was provided for stopping the rotation after a predetermined integral number of revolutions. The method has been used for comparing a small air-condenser with a microfarad. The capacity of the former was also calculated electro-statically (correction being made for the edges), and that of the latter measured electro-magnetically by a ballistic galvanometer. The results give a value for v equal to $2 \cdot 965 \times 10^{10}$. In these experiments the capacity of the rotating key was allowed for. Under favourable conditions, capacities in the ratio of 1 to 1000 or 1 to 10,000 can be compared with an accuracy of ¼ per cent. Prof. Ayrton thought the novelty of the arrangement was in the rotating key, as the method of comparing unequal capacities by charging the smaller and discharging it into the larger a considerable number of times had been described and used by himself and Prof. Perry in their experiments on the specific inductive capacity of gases. —Mr. W. Lant Carpenter exhibited a new form of lantern, recently constructed by Mr. Hughes, of Dalston. The mahogany body is hexagonal, and each of the three front sides is provided with condensers and projecting arrangements. The back side opens to give access to the radiant, which in this case is a Brockie-Pell arc lamp, but if necessary a lime-light can be readily substituted. The lamp is fixed to the base-board, and the body can be rotated through 60° on either side of the central position, thus allowing any of the three nozzles to be directed towards the screen. The three sets of condensers are placed so that their axes intersect at a point about which the radiant is placed. The centre nozzle is fitted as a lantern microscope, with alum cell and various sets of condensing lenses and objectives, and a space in front of the main condensers is provided for polarizing apparatus. The focussing arrangement consists of a skew rack and pinion and a fine screw adjustment, and the whole microscope can be easily removed and a table polariscope substituted. The right-hand nozzle is arranged for the projection of ordinary lantern-slides, and the left-hand one is provided with an adjustable slit for spectrum work. A small table sliding on rails serves to carry the prisms, and the same rails support projecting lenses. Prof. S. P. Thompson congratulated Mr. Lant Carpenter on his selection of the Brockie-Pell lamp as the radiant, for, in addition to its being a focussing-lamp, it is unique in the fact that it works satisfactorily on either constant current or constant potential circuits.—Note on some additions to the Kew magnetometer, by Prof. Thorpe, F.R.S., and Prof. Rücker, F.R.S. In their magnetic survey of Great Britain and Ireland the authors have experienced considerable difficulty in making the necessary adjustments of the small transit-mirror used for determining the geographical N. point from observations on the sun. To make the required adjustments it is necessary to obtain an image of the cross-wires reflected from the mirror; and owing to the large amount of extraneous light, and the insufficient illumination of the cross-wire, the image is difficult to see. To exclude extraneous light, a tube is placed between the transit-mirror and the telescope, and a small screen placed behind the mirror. The cross-wires are illuminated by light reflected from a small platinum mirror introduced between the eye-piece and the cross-wires, which are viewed through a hole in its centre. The mirror is placed at 45° to the axis, and reflects a considerable quantity of light on the cross-wires when directed towards a bright part of the sky. In some cases it is advisable to take observations of the sun without first adjusting the transit-mirror, and afterwards correct the error introduced thereby. To do this a finely-divided scale is placed in the plane of the cross-wires, and from the position of the image, as indicated on the scale, the correction can be made. Observations taken with the mirror in adjustment and others taken when out of adjustment, and subsequently corrected, give very concordant results. The Rev. Father Perry said the improvements described were of great importance, for difficulties similar to those experienced by the authors had caused him to abandon the Kew magnetometer for field work, and to use a theodolite instead.

Linnean Society, June 21.—Mr. F. Crisp in the chair.—Mr. F. W. Oliver exhibited the aquatic and terrestrial forms of *Trapella sinensis*, of which he gave a detailed account, illustrated by diagrams.—Dr. R. C. A. Prior exhibited a branch of the so-called "Cornish elm," and described its peculiar mode of growth, which suggested its recognition as a distinct species. In the opinion of botanists present, however, it was regarded as merely a well-marked variety of the common elm.—On behalf of Mr. R. Newstead, of the Grosvenor Museum, Chester, photographs and drawings of the little grebe, *Podiceps minor*, were exhibited to illustrate a peculiarity observed in the mechanism of the leg-bones.—Mr. A. W. Bennett exhibited under the microscope, and made remarks upon, filaments of *Sphæroplea annulina* (from Kew), containing fertilized oospores.—Mr. Thomas Christy exhibited specimens of natural and manufactured Kola nuts, and explained how the latter might always be detected.—The following papers were then read:—Dr. P. H. Carpenter, on the *Comatulæ* of the Mergui Archipelago.—Prof. P. Martin Duncan and W. P. Sladen on the *Echinoidea* of the Mergui Archipelago.—Mr. W. P. Sladen, on the *Asteroidea* of the Mergui Archipelago.—Mr. W. Bolus, on South African *Orchideæ*.—Mr. R. A. Rolfe, a morphological and systematic revision of *Apostasiæ*.

Geological Society, June 7.—Dr. W. T. Blanford, F.R.S. President, in the chair.—The following communications were read:—A letter from H.M. Secretary of State for India, accompanying some specimens of rubies in the matrix from Burma.—On the Sudbury copper deposits (Canada), by J. H. Collins.—Notes on some of the auriferous tracts of Mysore Province, Southern India, by George Attwood.—On the Durham salt-district, by E. Wilson. In this paper the author described the new salt-field in the North of England, occupying the low-lying country bordering the estuary of the Tees, and situated partly in Yorkshire and partly in Durham. The history of the rise and progress of the salt-industry in South Durham was given, since the first discovery of salt by Messrs. Bolckow, Vaughan, and Co., at Middlesborough, in the year 1859. The stratigraphical position of the saliferous rocks of the Durham salt-district was considered in some detail. The diverse views which have been previously expressed on this head were referred to, and reasons given for concluding that all the beds of rock-salt which have been hitherto proved in this field, and the red rocks with which they are associated, belong to the upper portion of the Trias, viz. to the Upper Keuper series (Waterstones subdivision). The probable area of this salt-field, the limits of the distribution, and varying depths of the chief bed of rock-salt were indicated, and the extent of its supplies pointed out. In conclusion, the author called attention to the waste, as well as to certain other disadvantages resulting from the process of winning the salt now in operation.—On the occurrence of *Calcisphæræ*, Williamson, in the Carboniferous Limestone of Gloucestershire, by E. Wethered.—Second note on the movement of scree-material, by C. Davison; communicated by Prof. T. G. Bonney, F.R.S.

Anthropological Institute, May 29.—Francis Galton, F.R.S., President, in the chair.—A paper by Mr. G. H. Kinahan was read, on rubbings from ancient inscribed stone monuments in Ireland.—Dr. Stewart gave an account of the inhabitants of Paraguay.

June 12.—The Rev. H. G. Tomkins read a paper on Mr. Flinders Petrie's collection of ethnographic types from the monuments of Egypt. The author classified the collection under the four heads of Westerns, Southerns, Asiatics, and Egyptians; and examined, in order, the races mentioned under each of these heads. Among the Westerns are the Tahennu, or fair people, who, as Egyptian mercenary troops, founded, by a prætorian revolt, the famous twenty-second dynasty, to which Shishak, the invader of Palestine, belonged. The Lebu, or Libyans, fall under this head; and the author identifies with them the light-complexioned, fair-haired, and blue-eyed brickmakers of the celebrated tomb of Rekhmara. The want of the long side-locks is not surprising, since they were slaves employed in the lowest drudgery. The Shardina furnished highly-trained soldiers to the Egyptian army of Rameses II. They wore helmets with two horns, crested with a disk, and seem to have been Sardinians. Under the head of Southerns we have very various and interesting types. It is curious to find, in the paintings, blacks with red hair; but it seems probable that the colour was produced by the use of dye. Mr. Tomkins gave a full description of the race of Pûn, and dwelt particularly upon the terraced mountains covered with incense-trees that caused so much astonishment to the officers of Queen Hatasu. He also gave a probable explanation of the origin of the remarkable features of Amenhotep IV., the celebrated Khu-en-aten, whose mother, Queen Tua, was distinguished for her beauty.

Mathematical Society, June 14.—Sir J. Cockle, F.R.S., President, in the chair.—The Vice-Chancellor of Cambridge University (Dr. C. Taylor), read a paper on the determination of the circular points at infinity.—Prof. M. J. M. Hill followed with a paper on the c- and p-discriminants of integrable differential equations of the first order.—Mr. Tucker (Hon. Sec.), communicated papers by Lord Rayleigh, Sec. R.S., on point-, line-, and plane-sources of sound.—Note on rationalization, by H. Fortey.—Applications of elliptic functions to the theory of twisted quartics, by Prof. G. B. Mathews.—Prof. Greenhill, F.R.S., communicated remarks on coefficients of induction and capacity and allied problems, in continuation of a former paper (January 1879).—The following were taken as read: electrical oscillations, by Prof. J. J. Thomson, F.R.S.; and demonstration of the theorem "that the equation $x^3 + y^3 + z^3 = 0$ cannot be solved in integers," by J. R. Holt.

Zoological Society, June 5.—Dr. Edward Hamilton, Vice-President, in the chair.—The Secretary read a report on the additions that had been made to the Society's Menagerie during the month of May.—Mr. H. E. Dresser exhibited a specimen of a new Shrike from the Transcaspian district of Central Asia, which he proposed to name *Lanius raddei*, after Dr. Radde, of Tiflis, its discoverer.—Mr. Sclater, on the part of Mr. F. M. Campbell, exhibited a pair of Pallas's Sand-Grouse (*Syrrhaptes paradoxus*), shot in Hertfordshire in May last, and made remarks on the recent immigration of this Central Asiatic bird into Western Europe.—The Secretary exhibited, on behalf of Prof. R. Collett, a nest, eggs, and two young ones in down of the Ivory Gull (*Larus eburneus*), belonging to the Tromsö Museum, which had been obtained in Spitzbergen in August 1887.—Mr. Warren communicated a paper on Lepidoptera collected by Major Yerbury in Western India in 1886–87, forming a continuation and completion of two previous papers by Mr. A. G. Butler on Lepidoptera collected by the same gentleman in similar localities. The present collection contained examples of over 200 species of Heterocera, of which about one-fourth were described as new. Mr. Warren remarked upon the abnormal development of separate organs, such as the antennæ and palpi, in tropical insects, as being rather specific aberrations from a generic type, than as warranting the erection of new genera.—A communication was read from Mr. Martin Jacoby, containing descriptions of some new species of Phytophagous Coleoptera from Kiukiang, China.—Mr. F. E. Beddard read some notes on the structure of a peculiar sternal gland found in *Didelphys dimidiata*.—Mr. G. A. Boulenger read a paper on the scaling of the reproduced tail in Lizards, and pointed out that the scaling of the renewed tails of Lizards may, in some cases, afford a clue to the affinities of genera or species to one another.—Mr. F. E. Beddard gave a preliminary notice of an apparently new form of Gregarine, found parasitic on an earthworm o the genus *Perichæta* from New Zealand.

CAMBRIDGE.

Philosophical Society, May 21.—Mr. J. W. Clark, President, in the chair.—On solution and crystallization, by Prof. Liveing. When a substance passes from a state of solution into the solid state, the new arrangement of the matter must be such that the entropy of the system is a maximum; and, other things being the same, the surface energy of the newly-formed solid must be a minimum. If the surface tension be positive, that is tend to contract the surface, the surface energy will be a minimum when the approximation of the molecules of the surface is a maximum. The essential difference between a solid and a fluid is that the molecules of the former maintain approximately the same relative places, whereas the molecules of a fluid are subject to diffusion. Further, crystalloids in assuming the solid form assume a regular arrangement of their molecules throughout their mass, which we can usually recognize by the optical properties of the crystal, and by the cleavage. If we suppose space to be divided into equal cubes by three sets of parallel planes, each set at right angles to the other two, and suppose a molecule to be placed in every point where three planes intersect, we shall have an arrangement which corresponds with the isotropic character of a crystal of the cubic system. But of all the surfaces which can be drawn through the system the planes bounding the cubes meet the greatest number of molecules, those parallel to the faces of the dodecahedron meet the next greatest number of molecules, and those parallel to the faces of the octahedron meet the next greatest number. Also if we take an angular point of one of the cubes as origin, and three edges of the cube as axes, and the length of an edge of the cube as the unit of length, every plane which cuts the three axes at distances p, q, r respectively from the origin, where p, q and r are whole numbers, will be a surface of maximum concentration of molecules, but the concentration will be less as p, q and r are greater. Hence forms which are bounded by these planes, which follow the law of indices of crystals, will be forms of minimum surface energy and therefore of equilibrium. The tendency in general will be for substances with such a structure as is here supposed to take the form of cubes, since the cube will have the greatest concentration of molecules per unit of surface. But the total surface energy will depend on the total surface as well as on the energy per unit of surface, and for a given volume the surface will be diminished if the edges and angles of the cube are truncated by faces of the dodecahedron and octahedron, or by more complicated forms. When a solid is broken, two new surfaces are formed each with its own surface energy, and the solid must be more easily fractured when the new surfaces have the minimum energy. Hence substances with the structure supposed must break most easily in directions parallel to the sides of the cube, dodecahedron and octahedron; and these are the cleavages observed in this system. If we suppose the molecules placed at the centres of the faces of the cubes, instead of at the angles, the arrangement will still be isotropic, but the octahedron will be bounded by the surfaces of greatest condensation, and the cube will come next to it. It is probable that substances which cleave most readily into cubes, such as rock-salt and galena, have the former structure, while those which have the octahedral cleavage may have the latter arrangement of their molecules. For the pyramidal and prismatic systems we may suppose space divided not into cubes but into rectangular parallelopipeds with edges equal severally to the axes of the crystals, and molecules placed as before. For the rhombohedral system we may suppose space divided into rhombohedra, or in crystals of the hexagonal type into right prisms with triangular bases, and for the other systems into parallelopipeds with edges parallel and equal to the axes. In each case if the molecules be disposed at points of intersection of three dividing planes we shall have such an arrangement as satifies the optical conditions, and planes which follow the law of indices are surfaces of maximum condensation. Calculations show that whenever a crystal has an easily obtained cleavage the direction of cleavage corresponds to the surface of greatest condensation, and that the most common forms of crystals correspond in general to forms of minimum surface energy. The surface tension of a plane surface will have no resultant out of that plane, but where two plane surfaces meet in an edge, or angle, the tensions will have a resultant of sensible magnitude in some direction falling within the angle. Whenever all the faces of a crystallographic form are developed, every such resultant will be met by an equal and opposite resultant, and the form will be one of equilibrium. If one edge, or angle, be modified, the opposite edge, or angle, must either be similarly modified, or the resultant arising from the modification must be equilibrated by some internal forces produced by displacement of the molecules. In general, equilibrium is attained by similar modifications of similar edges and angles, but when only some of the edges or angles of a crystal are modified, while other similar edges or angles are not modified, we usually have evidence of the consequent internal strain. Thus cubes of sodium chlorate, which have half the angles truncated by faces of a tetrahedron, rotate the plane of polarized light, hemihedral tourmalines are pyro-electric, and so on. This theory therefore accounts for the plane faces of crystals, the law of indices, the most common combinations, and the cleavages. The same theory accounts for the development of plane faces when a crystalline solid of any shape is slowly acted on by a solvent. Solution will proceed so long as the entropy of the system is increased by the change, but when the solution is nearly saturated there will be an increase of entropy from the solution of a surface which has more than the minimum surface energy, while there will be no increase from the solution of a surface which has only the minimum energy.—On the effect of an electric current on saturated solutions, by Mr. C. Chree, M.A. This paper contains an account of experiments whose aim was to determine what effect, if any, an electric current may have on the quantity of salt required to form a saturated solution. Strong currents and a rapidly reversing commutator were employed. Certain chlorides were dealt with, and in no case did the existence of a current produce any sensible immediate effect. When heating was allowed to take place, the action of the current appeared to check the solution that would naturally have followed. This view was further supported by experiments on the effects of simple heating. These experiments showed, however, that an originally saturated solution when slowly heated can dissolve salt only with extreme slowness.

PARIS.

Academy of Sciences, June 18.—M. Janssen, President, in the chair.—Lagrange's hypothesis on the origin of comets and meteorites, by M. H. Faye. According to the author's calculations, this hypothesis, first submitted to the Bureau of Longitudes in 1812, does not hold good for the comets whose orbits do not quite approach any of the planetary orbits. But it would seem capable of being applied to the meteorites, whose fragmentary character, minute size, chemical and mineralogical identity with the constituent elements of the earth, combined with their great abundance, would seem to be absolutely incompatible with an extra-planetary origin. The earth alone with its satellite best satisfies all the conditions of the problem, while its orbit is continually intersected by millions of these bodies, as required by the hypothesis in question. Hence their origin is to be sought in the earth itself and in the moon, whence they were ejected under conditions which have long ceased to exist.—Fluorescence of ferruginous lime, by M. Lecoq de Boisbaudran. These experiments show that a small quantity of the sesquioxide of iron added to the carbonate of lime produces a green fluorescence after high calcination in the air. This fluorescence, which is occasionally somewhat intense, is very sensitive to the action of heat; hence it soon fades away in the presence of the electrode, retaining its brilliancy only in the parts of the tube furthest removed from the centre of action.—Experimental researches on the diseases of the vine, by MM. Pierre Viala and L. Ravaz. Having already shown that the different reproductive organs found on the parts affected by black rot belong to the fungus, cause of this disease, the authors here demonstrate the true parasitic character of the fungus itself. They once for all establish the filiation which exists between its various forms of reproduction, and thus make it evident that the blight on the leaves has the same origin as that of the grapes.—Researches on the accidental errors occurring in the observations of transits made by the method of eye and ear, by M. G. Rayet. In supplement to the studies of Struve, Robinson, Dunkin, Finlay, and others, the author here describes the results of special observations made on about seventy stars, or constellations, comprised between 20° of austral declination and the North Pole. He has thus determined the numerical value of the accidental errors relative to some dozen stars between 80° and 89° 22'·3 of declination.—On the rings of Saturn, by M. Perrotin. During the opposition of Saturn in the present year the author has made a series of micrometric measurements of the rings by means of the great equatorial of the Observatory of Nice. The results of these observations, made for the purpose of determining the dimensions of the system, are here fully tabulated for the whole period from February 2 to May 8.—On the planet Mars, by M. Perrotin. On presenting the already promised sketches of recent appearances in this planet, the author remarked that since his last communication the region of Libya has undergone fresh modifications. The sea which covered the surface of this insular mass has mostly receded, its present appearance being intermediate between that of 1886 and its condition a few weeks ago. The existence has also been determined of canals or channels, partly double, running from near the equator to the neighbourhood of the North Pole. They mainly follow the meridian, and merge in the seas encircling the white snow-cap of the Pole, and, strange to say, their course may be followed across the seas themselves right up to the snow-cap.—Heat of combination of the primary, secondary, and tertiary aromatic monamines with the acids, by M. Léo Vignon. In continuation of M. Louguinine's study of the primary monamines, the author here investigates the reactions of several acids on a series of primary, secondary, and tertiary monamines. He deals more especially with aniline, monomethyl aniline, and dimethylaniline in the presence of the hydrochloric, sulphuric, and acetic acids.—On the decomposition of the ferrate of baryta at high temperatures, by MM. G. Rousseau and J. Bernheim. In his researches on ferric acid, Fremy has indicated the analogy existing between the ferrates and the manganates, as established by the wet process. Here the authors endeavour to ascertain whether the parallelism is maintained in the reactions of the dry process and in their mode of decomposition under the action of heat.—On some new double phosphates in the magnesian series, by M. L. Ouvrard. The products here described have been obtained by the method already referred to in a previous note on the action of the alkaline phosphates on the alkaline earthy oxides. All the metals investigated are allied in their composition to the substances obtained with the pyro- and ortho-phosphates of potassa and soda.—On the poison of the Hymenoptera with smooth sting, and on the existence of a poison-cell in the honey-producing insects, by M. G. Carlet. In continuation of his researches on the barbed sting of bees, wasps, &c., the author here studies the smooth sting of Philanthus, Pompilus, &c. He describes the nature of the poison, which has merely a soporiferous effect, and clearly determines the presence of a poison-cell in bees and allied insects.—On a new bacterial disease of the duck, by MM. Cornil and Toupet. An examination of the bacteria of this disease ("duck cholera") shows that it is quite distinct from chicken cholera. The virus is fatal to the duck alone, sparing hens and pigeons, and killing rabbits only when an excessive dose is administered.—M. A. d'Arsonval contributes an elaborate paper on the relation between animal electricity and surface tension.

AMSTERDAM.

Royal Academy of Sciences, May 26.—M. Franchimont, communicating the results of experiments on nitro-ureides and nitramines, said that internal ureides, by their behaviour with nitric acid, may be distinguished into at least three sorts.—M. Sahols treated of the calculation of the moments of flexion and the shearing-forces in railway-bridges, in connection with the irregular distribution of the pressures exercised by the axles of locomotive-engines. He pointed out what elements of the engine are of especial influence on these, and arrived at very simple approximative formulæ for the calculation of the said moments and forces on bridges of not too insignificant length.—M. Pekelharing read a paper on the proliferation of endothelium-cells in arteries, stating, as the result of his experiments made upon them, that this proliferation is most probably caused by a diminution of the pressure upon the inner wall of the arteries.—M. van der Waals treated of the connection between the change in the density of the limiting layer between fluid and vapour, and the mode of action of the molecular forces.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Proceedings of the Royal Society of Edinburgh, Sessions 1883 to 1887 (Edinburgh).—Transactions of the Royal Society of Edinburgh, vol. xxx. Part 4, vol. xxxii. Parts 2, 3, 4, vol. xxxiii. Parts 1, 2 (Williams and Norgate).—Transactions of the Royal Society of Edinburgh, vol. xxxi. Botany of Socotra: Prof. I. B. Balfour (Williams and Norgate).—British Reptiles and Batrachians: C. C. Hopley (Sonnenschein).—Anleitung zu Wissenschaftlichen Beobachtungen auf Reisen, Bands 1 and 2: Dr. G. Neumayer (Oppenheim, Berlin).—Mathematical Drawing Instruments, sixth edition: W. F. Stanley (Spon).—Proceedings of the American Association for the Advancement of Science, New York Meeting, 1887 (Salem).—British Dogs, Parts 17 to 20: H. Dalziel (U. Gill).—Observations made at the Hong Kong Observatory in the year 1887: W. Doberck (Hong Kong).—Synopsis of the Aphididæ of Minnesota: O. W. Oestlund (St. Paul).—Report on Botanical Work in Minnesota for the year 1886: J. C. Arthur (St. Paul).—Preliminary Description of the Peridotytes, Gabbros, Diabases, and Andesytes of Minnesota: M. E. Wadsworth (St. Paul).—Palæolithic Man in Eastern and Central North America (Cambridge, Mass.).—Journal of the Royal Microscopical Society, June (Williams and Norgate).—Proceedings of the Society for Psychical Research, June (Trübner).—Sulla Forza Elettromotrice del Selenio, Memoria del Prof. A. Righi (Padova).

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