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SCIENTIFIC WORTHIES

XVII.—ROBERT WILHELM BUNSEN

THE value of a life devoted to original scientific work is measured by the new paths and new fields which such work opens out. In this respect the labours of Robert Wilhelm Bunsen stand second to those of no chemist of his time. Outwardly the existence of such a man, attached, as Bunsen has been from the first, exclusively to his science, seems to glide silently on without causes for excitement or stirring incident. His inward life however is on the contrary full of interests and of incidents of even a striking and exciting kind. The discovery of a fact which overthrows or remodels our ideas on a whole branch of science; the experimental proof of a general law hitherto unrecognised; the employment of a new and happy combination of known facts to effect an invention of general applicability and utility; these are the peaceful victories of the man of science which may well be thought to outweigh the high-sounding achievements of the more public professions.

Prof. Bunsen is eminently a soldier of science, his devotion to his flag has been unwavering and life-long, and his whole existence has been a noble struggle for the mastery of nature's secrets. Born on March 31, 1811, at Göttingen, where his father was Professor of Theology, Bunsen graduated in that ancient University before he had passed through his teens, and published an inaugural dissertation, "Enumeratio ac descriptio hygrometorum." Soon afterwards, at the age of twenty-two, he became a privat-docent at the university of his native town, thus entering the career of a teacher, which he has consistently followed with conspicuous success for close on half a century. In 1836 Bunsen became Professor of Chemistry at the Polytechnic School in Cassel; in 1838 he was appointed to the Chair of Chemistry in the University of Marburg, where he remained for thirteen years; afterwards he was for a short time at Breslau, whence he removed to Heidelberg, of which renowned University he has been one of the chief ornaments and attractions for the last thirty years.

Bunsen's first scientific investigation was one which attracted general attention, and the results of which are of permanent importance. In conjunction with Berthold, a colleague at Göttingen, he showed that moist freshly precipitated ferric hydroxide acts as a certain antidote in cases of poisoning by arsenic, provided that it is exhibited in sufficient quantity and early enough in the history of the case. The explanation of this action is the formation of an insoluble ferrous arsenite; 100 parts of the dry hydroxide carry down from five to six parts of arsenic. So well known and valued is this antidote in Germany, that it is kept by apothecaries ready for use.

In 1835 Bunsen described some singular compounds which the double cyanides form with ammonia. He contradicted the general statement that ammonium ferrocyanide is formed by boiling prussian blue with ammonia; but showed that it is formed by digesting lead ferrocyanide with ammonium carbonate. He also measured the angles of crystals of many of the double cyanides.

In 1837 he struck the first note of one of his most important and fruitful investigations in a memoir on the existence of arsenic as a constituent of organic bodies. In the year 1760 the French chemist Cadet had observed that a mixture of acetate of potash and white arsenic yields, when heated, a heavy brownish-red liquid, which has a frightful smell and fumes strongly in the air, and this liquid was termed Cadet's fuming arsenical liquid. Little more than the fact of its existence was ascertained concerning this body until Bunsen undertook its examination, and in a series of memoirs which have now become classical, and which extended over many years, placed its composition in a true light, thus giving to the world the first member of the now well-known family of the organo-metallic bodies.

Bunsen showed that Cadet's liquid, as well as its numerous derivatives, contains a radical having the formula C_2H_6As, and that this substance in its chemical relations exhibited striking analogies with a metal, being indeed, as he terms it, "a true organic metal." He succeeded in isolating this body, and this discovery formed not only the starting-point for the preparation of hundreds of other similar bodies, but also contributed largely to the development of one of the most important of our chemical theories, that of compound radicals. This body, like most of its compounds, possesses a most offensive odour, so much so that the air of a room containing a trace of the vapour is rendered absolutely unbearable. Hence to this substance Bunsen gave the name of Cacodyl (*κακώδης*, a bad smell). Not only however are these compounds unpleasant, but they are highly poisonous, very volatile, dangerously explosive, and spontaneously inflammable. It is difficult enough nowadays for a chemist to work with such substances armed as he is with a knowledge of the danger which he has to encounter, as also with improved appliances of every kind to assist him in overcoming his difficulties. But Bunsen forty years ago was a traveller in an unknown and treacherous land, without sign-posts to guide him, or more assistance on his journey than was furnished by his own scientific acumen and his unfaltering determination. Nor did he escape scot-free from such a labour, for in analysing the cyanide of cacodyl the combustion tube exploded, Bunsen lost the sight of an eye, and for weeks lay between life and death owing to the combined effects of the explosion and the poisonous nature of the vapour. "This substance," he writes, "is extraordinarily poisonous, and for this reason its preparation and purification can only be carried on in the open air; indeed, under these circumstances it is necessary for the operator to breathe through a long open tube so as to ensure the inspiration of air free from impregnation with any trace of the vapour of this very volatile compound. If only a few grains of this substance be allowed to evaporate in a room at the ordinary temperature, the effect upon any one inspiring the air is that of sudden giddiness and insensibility, amounting to complete unconsciousness."

Taking a totally different direction, Bunsen's next important investigations were concerned with the examination of the chemical changes which occur in the blastfurnace. In 1838 he proved, by accurate analyses of the gases escaping, "that at least 42 per cent. of the heat evolved from the fuel employed is lost, and that in view of the ease with which such combustible gases can be collected and led off to a distance for subsequent use, a new and important source of economy in the iron manufacture is rendered possible." This research is however not only noteworthy as pointing the way to a method of economical working without which probably but few iron-masters at the present day could exist, but also as being the first experiment in which an accurate method of gas-analysis was employed. This important branch of analytical chemistry has been created and brought to its present wonderful degree of precision solely by the head and hands of the Heidelberg experimental philosopher. Simplicity and accuracy constitute the rare merits of Bunsen's system of gaseous analysis. To have gone completely through his course of gas analytical manipulations from the sealing-in of the platinum wires in the eudiometer to the absorption- and explosion-analyses of the Heidelberg coal-gas, under the eye and with the guilding help of the hand of the master, is in itself an experimental education of no mean order. But it is only on reference to his "Gasometric Methods" that we learn the general adaptability of this marvellously accurate system to all those numerous problems in which the analysis of a mixture of gases is required.

Next in order (1841) comes the invention of the Bunsen battery, an invention which has proved of the greatest practical value to mankind, inasmuch as this form of battery is now very largely used all over the world, not only as a scientific instrument, but also for ordinary telegraphic purposes. The chief point in this invention consists in the employment of carbon as the negative pole in place of copper or platinum. In his first communication on this subject, Bunsen accurately measures the absolute intensity of the current from his zinc-carbon battery, and compares it with that of a Grove (zinc-platinum) battery, invented a short time before by Sir William Grove.

Bunsen's next great achievement consists in the investigation from both the chemical and the physical point of view of the volcanic phenomena of Iceland. The several memoirs on this subject are the result of a visit to Iceland in 1847. They consist, in the first place, of a careful and extended series of analyses giving the average composition of the volcanic rocks of different ages occurring in the island, upon which he founded a most important and very general theory of volcanic action, a theory which he has since proved is applicable to the formation of other volcanic rocks of widely different origin, both as regards time and locality. This theory consists, to begin with, in a proof that all the Islandic rocks, of whatever age, may be considered as mixtures in varying proportions of two normal silicates, the trachytic and pyroxenic. In the first of these (an acid silicate) the relation of the oxygen of the acid to that of the bases is as 3 : 0·596, whilst in the latter (a basic silicate) the relation is as 3 : 1·998. This result, accompanied by an experimental proof that the melting-point of different bodies is differently raised under increase of pressure, led Bunsen to assume that a crystallisation of these two normal silicates occurs in the earth's interior, and that all the eruptive rocks which reach the surface consist either of one or other of these or of mixtures of the same. In the next place they contain a full and successful research on the so-called pseudo-volcanic phenomena of Iceland, in which he investigates the formation of zeolites and other crystalline minerals by the joint action of heat, acid gases, and moisture on the volcanic rocks. He also examines the composition of the fumerolle gases as well as those issuing from the crater of Hecla, and explains the nature of the changes effected by these gases on the surrounding rocks. Lastly, he investigates the far-famed Great Geyser, and places the cause of the periodic eruption of boiling water on its true physical basis. His accurate observations on the spot, first as to the construction of the geyser-tube, then as to its mode of formation, and finally, his thermometric measurements of the temperature of the water-column taken a few moments before the eruption and at different depths, disposed once for all of what may be called the old tea-kettle theory, and showed indisputably that in no part of the tube did the water reach the temperature of ebullition under the pressure of the superincumbent column, whilst the column is quiescent, but that when the geyser column is elevated by the rush of steam from the volcanic vents at the bottom, the boiling-point of the water at each point of the column thus raised is reached, and "the whole mass from the middle downward suddenly bursts into ebullition, the water above mixed with steam-clouds is projected into the atmosphere, and we have the Geyser eruption in all its grandeur. By its contact with the air the water is cooled, falls back into the basin, partially refills the tube in which it gradually rises, and finally fills the basin as before. Detonations are heard at intervals, and risings of the water in the basin. These are so many futile attempts at an eruption, for not until the water in the tube comes sufficiently near its boiling-point to make the lifting of the column effective can we have a true eruption" (Tyndall).

To do justice to all the contributions with which Bunsen has enriched our science would fill several numbers of NATURE, and to many of them the writer must content himself with a mere cursory reference. One of his favourite and fruitful themes was the preparation by electrolysis of the rarer or more difficultly procurable metals. This is one of the purposes for which he employed his battery. Metallic magnesium was one of the first of his preparations of this kind, and in the description of this preparation his fertility of resource is clearly seen. Metallic magnesium in the molten state is specifically lighter than the fused mixture of salts from which it is obtained. Hence as soon as a globule of the metal is formed, it rises to the surface, and there takes fire and burns. To obviate this difficulty the carbon pole on which the metal was formed was serrated, and the metal on rising was caught, below the surface of the fused salt, in one of a series of small pockets, and thus prevented from burning.

Then followed the reduction of chromium, aluminium, and, in conjunction with the late Dr. Matthiessen, that of the alkaline-earth metals, and more recently with Hillebrand and Norton, of the metals of the cerium, group. These electrolytic researches are marked with the thoroughness and completeness which is characteristic of all Bunsen's work. He seeks for the explanation of the fact that hitherto the reduction of these metals by the electric current had proved a failure, and he finds it in what he terms the density of the current, *i.e.* the electromotive force divided by the area of the pole, the power of the current to overcome chemical affinity increasing with its density. Thus if a constant current be led through an aqueous solution of chromic chloride, the result as to whether hydrogen is evolved, and oxide of chromium, or whether metallic chromium is deposited, depends upon the area of the pole through which the current passes into the liquid.

Nor were these experiments made merely for the purpose of preparing the metals in question. Thus the metallic magnesium was pressed into wire and used in one of the series of photo-chemical researches, to which reference will hereafter be made, for the purpose of drawing an interesting conclusion respecting its light-giving power on combustion, and comparing this with the visual and chemical brightness of the sun, a comparison which led to the commercial manufacture of this metal by the Magnesium Metal Company, and to the wide distribution and general use of this metal as an illuminating agent of great brilliancy. Thus again the electrolytic preparation in the Heidelberg laboratory of coherent masses of cerium, lanthanum, and didymium, had the further object of the determination of the specific heat of these metals by help of the now well-known method with Bunsen's ice-calorimeter, by means of which determination the true atomic weights of these metals and the proper formulæ of their oxides and compounds have been definitely ascertained.

The Bunsen battery has however not only been of service in inorganic chemistry, but has thrown clear light upon the constitution of organic bodies. The classical researches of Kolbe on the electrolysis of acetic acid and the other fatty acids were carried out in the Marburg laboratory, and owe their inspiration to Bunsen. The subsequent equally important labours of Kolbe and Frankland, and those of the latter chemist alone, on the isolation of the organic radicals, have a like origin.

Amongst the numerous physico-chemical investigations which Bunsen has carried out, none perhaps show more clearly the fertility of his experimental ability than the one in which he describes the ice calorimeter, and another devoted to an explanation of a new method of determining vapour densities. Translations of these memoirs are found in the *Philosophical Magazine* for 1867 and 1871, and may be taken as typical of his calorimetric researches.

Another group of researches is formed by those which are closely related to his gasometric methods. One of the most interesting and important of these refers to the law of absorption of gases in water. This subject was first examined by Dalton and Henry at the beginning of the century, and the well-known law which gases follow in absorption is known by the names of these two Manchester philosophers. But although generally admitted, its limits of error had not been ascertained, and the crude experimental methods of the year 1803 required to be replaced by the refined ones of the latter half of the century. These researches, carried on by Bunsen and by several of his pupils, proved that Henry's law of direct—as well as that of Dalton of partial—pressures is exactly true within certain limits; but ceases to be so beyond a given increase of pressure, whilst some gases which obey the law at one temperature do not do so at others, and some again whilst obeying it in the pure state, do not do so when mixed with other gases.

The mere mention of his other researches in the wide field of gaseous chemistry is sufficient to indicate his devotion to this branch of experimental inquiry. We find experiments on laws of gaseous diffusion, on applications of gaseous diffusion in gasometric analysis, on the phenomena of the combustion of gases, on the temperature of ignition of gases, and all these, be it remembered, involving exact measurement, and in many cases elaborate calculations.

Brief reference must next be made to a series of investigations in a totally different direction, viz. on the measurement of the chemical action of light, with the carrying out of which the writer of this article had the great good fortune and pleasure to be connected, and in which he had full opportunity of admiring Bunsen's untiring energy and wonderful manipulative power. In all the difficulties and perplexities by which the experimental investigation of such a subject is beset, the writer never knew Bunsen discouraged or at a loss for an expedient by which an obstacle could be overcome. Cheerful and self-reliant under the most depressing circumstances, he never gave up hope, and thus it was that these somewhat intricate and difficult investigations were brought to a successful close.

Again, in the department of Analytical Chemistry how numerous and valuable have been his contributions! There is scarcely one important problem in this subject which has not benefited from his extensive experience and keen insight. Bunsen's methods of silicate analysis, of mineral water analysis, and a dozen of other complicated laboratory processes, are simply perfect. Then his original method for the estimation of nitrogen in organic bodies will always be remembered as one of the most accurate of its kind when employed by an experimentalist as expert as Bunsen himself, but as most difficult and even dangerous in less able hands. Again, all chemists use and appreciate the much simpler methods for the estimation of nitrogen and sulphur admirably worked out by his pupils—Maxwell Simpson and Russell.

We all employ his beautiful general method of volumetric analysis, but chemists do not always remember that in this research Bunsen first determined the exact percentage composition of the higher oxide of cerium, a determination of the greatest scientific importance as regards the chemistry of the metals of the rare earths. Moreover they may be apt to forget that Bunsen was the first to introduce a general method of the separation of these rare earths, by which he for the first time prepared pure yttria and erbia, and by which subsequently, in the hands of other chemists, many new metals have been discovered. His well-known method of flame-reactions is a standard example worked out by every student. Again, modern chemists can now scarcely carry on the simplest experiment without using the "Bunsen gas-lamp," a burner which is also now employed in every household, and in many manufactories, and has become so necessary that it is difficult to conceive how we worked before its invention. To him we are also indebted for the apparatus for accelerating filtration, the "Bunsen-pump," together with all its appliances, now employed in every laboratory.

Of all the contributions to the advancement of our science, that by which the name of Bunsen has, however, become best known, and by virtue of which future generations will place him on the highest pinnacle of experimental fame, is the foundation, with his no less celebrated colleague Kirchhoff, of the science of Spectrum Analysis, and the discovery by its means of the two new alkali metals, cæsium and rubidium. It is true, of course, that many facts were ascertained and many observations made relating to the power possessed by matter in the state of incandescent gas emitting rays of a peculiar and characteristic kind. Few great discoveries are made at one step. But the glory of having established a new branch of science, of having placed "Analysis by Spectrum Observations" on a sound and firm experimental basis, belongs to the Heidelberg philosophers, and to them alone.

The history of the establishment of spectrum analysis, as that of its enormous recent developments, is too well known to the readers of NATURE to require repetition. All that is necessary here is to recall the masterly way in which Bunsen worked out the properties and showed the relationships of the new metals and their compounds. He first saw the cæsium lines in a few milligrams of the alkaline residue obtained in an analysis of the Dürkheim mineral waters, and the discovery of a second new metal (rubidium) soon followed that of the first. So certain was he of the truth of his spectroscopic test that he at once set to work to evaporate forty tons (44,000 kilos) of the water, and with 16·5 grammes of the mixed chlorides of the two new metals which he thus obtained, he separated the one metal from the other (no easy task) and worked out completely their chemical relationship and analogies, so much so that the labours of subsequent experimenters have done little more than confirm and extend his observations; such a result is truly a marvel of manipulative skill!

Another less widely known, but no less interesting and important research, is that on the spark-spectra of the metals contained in cerite and other rare minerals. In this he shows his power both as physicist and chemist. He first describes a new chromic-acid battery suited to the performance of the special experiments which he afterwards details. He determines with great care all the physical constants of this battery, and then proceeds to investigate the spectra of the earths which give no colour to the non-luminous flame. The spark-spectra of these earths he carefully maps, so completely, indeed, that the separation and identification of these metals now for the first time became possible.

The many hundreds of pupils who during the last half-century have been benefited by personal contact with Bunsen will all agree that as a teacher he is without an equal. Those who enjoy his private friendship regard him with still warmer feelings of affectionate reverence. All feel that to have known Bunsen is to have known one of the truest and noblest-hearted of men.

H. E. ROSCOE

JAPAN

Japan, nach Reisen und Studien in Auftrage der k. Preuss. Regierung dargestellt. Von J. J. Rein, Professor der Geographie in Marburg. Erster Band. Natur und Volk des Mikadoreiches. (Leipzig: Engelmann, 1881.)

Notes and Sketches from the Wild Coasts of Nipon. By Capt. H. C. St. John, R.N. (Edinburgh: Douglas, 1880.)

THE present year has already brought two new contributions to the rapidly increasing stock of Japanese literature in "Japan, nach Reisen und Studien," by Prof. Rein of Marburg, and "The Wild Coasts of Nipon," by Capt. St. John. The two works thus thrown into association by subject and time of publication have however nothing else in common.

Had Capt. St. John's book been written a few generations ago, or had it related to a country previously unexplored, it would have possessed a greater claim upon popular interest; but Japan has in late years been so far the object of careful study by residents, and of descriptions by tourists, that the *raison d'être* of "The Wild Coasts of Nipon" is not easy to perceive.

In the preface the reader is assured that everything stated in the text, with a few exceptions, came under the observation of the author, and there is no doubt that he has scrupulously confined himself to his own personal experience, without seeking to correct or augment it by reference to other sources. The advantage of such a limitation of matter must however depend altogether upon the extent of the experience and the special qualifications of the observer, and we are of opinion that had the author taken the trouble to ascertain what his predecessors have already made known, he would have largely altered his notes.

The author as a sportsman and naturalist displays himself in a more favourable light than as a logician and observer. His sporting memoranda are amusing, and give a character to the volume, while as an amateur naturalist he shows more than average knowledge, and contributes some interesting facts on the subject of the animal kingdom. In the flora he is on less secure ground, and on one occasion, at page 137, confuses, in name at least, two such well known trees as the Hinoki (*Retinospora obtusa*) and the *Cryptomeria Japonica*.

In his remarks upon the people he bears good witness to the simplicity and kindness of the peasantry, of whom he must have seen a good deal. Unfortunately, for a traveller unlearned in the language, and chiefly dependent for his entertainment upon ordinary tea-houses, he has rather rashly ventured into generalisations requiring information that very few foreigners possess. At page 182 the Japanese men, as a race, are said to be "well made, muscular, active, and strong, and averaging about five feet five inches[1] in height," a description applying fairly well to the northern fishermen, but certainly flattering to the nation in general. Again, in several places the author follows a common fashion in deploring the evils brought upon the people by European "civilisation," but makes no allusion to the greater evils it is now

[1] Dr. Rein's estimate of the average height of the men is 150 centimetres. This is nearly as much below the mark as Capt. St. John's calculation is above it.

expelling, and ignores the fact that any deterioration which has followed the recent change of circumstances is not the work of "civilisation," but of the vile or foolish camp-followers that may cling to the skirts of even the noblest army.

Upon the religion of the country he says little more than is to be found in a footnote at page 127; but students may be interested to learn from this that "Shinto is never represented by any figure, but worshipped as the Unseen Spirit which pervades everything. Buddha, as is well known, is always represented by a male figure; Shinto, the unrepresented, is supposed to be a female."

Criticism of the volume is to some extent disarmed by the modesty of its preface, and it no doubt contains much that will amuse the general reader.

In Dr. Rein's "Japan" we have the work not only of a *savant* thoroughly versed in his subject, but of a practised literary architect. The present volume deals with the geographical conformation, climate, flora, and fauna of the Japanese group, and the history, ethnography, and religion of the people, concluding with a useful chapter on topography. A future volume is to comprise an account of the industries and commerce, and will be welcomed by all who read the part now before us.

The geographical summary is far more complete and accurate than any to which the public has yet had access, and at every page shows the hand of an expert who has brought original knowledge and personal observation to bear upon his task. The climatic peculiarities are for the first time (save by the author himself in 1876) systematically described, and all the more important meteorological details accumulated in the past eighteen years in different parts of the country are reproduced in tabular form.

In the study of the flora and fauna the accumulation of facts is already too large to allow the author to go far beyond the limits of enumeration. Since Dr. Rein's account has been written a new addition has been made to the fauna in a catalogue of the birds of Japan by Capt. Blakiston and Mr. Pryer, and the number of known species raised from about 250 to 325, of which about 180 occur also in China, and about 100 are represented in Great Britain.

It is to be regretted that space could not have been spared for a little supplementary information upon some of those members of the animal kingdom which possess a more popular interest. For example, a few details respecting the dangerous and unpleasantly common *Mamushi* (*Trigonocephalus Blomhoffii*) and the wrongly maligned little *Hibakari* (*Tropidonotus Martensii*) would have been useful. The poisonous properties of certain species of the *Fugu* or genus *Tetrodon* are pointed out, and the symptoms produced by their use as food described; but in the reference to the "*hungerige, blutgierige Mosquitos*," though feeling tribute is paid to the vexatious side of their character, the grave charges to which they are open are omitted, their probable agency, long recognised by native physicians, in the conveyance of malignant pustule, and the suspicion raised by Dr. Patrick Manson's investigations in Amoy, that the spread of Elephantiasis Arabum in the south of Japan is due to the same pest.

The second and less technical part of the book embraces subjects upon which the author is less able to speak *in verbâ magistri* than on geographical science. The section, "Das Japanische Volk," opens with an historical abstract of about 200 pages, compiled from Klaproth, Kæmpfer, Siebold, Satow, Aston, and other authorities. The purely mythical stories of the age of the gods are passed over rapidly, and the commencement of the history of the country is fixed at the reign of Jimmu Tenno (660 to 585 B.C.). Dr. Rein is generous enough to acknowledge without question the reputed founder of the imperial lore, of whose existence there is little more proof than of that of the *Uwabami* and *Kamaitachi*, which the Professor does not consider entitled to a place in the fauna. As is mentioned in a footnote, the earliest written records extant originated in the first part of the eighth century of our era, and admitting the possibility that these were compiled from lost manuscripts of older date, they still offer satisfactory internal evidence that the historical being of Japan is at least a thousand years younger than is indicated by the list of the ancient emperors from whom the reigning Mikado traces his descent. The fact will perhaps be sufficiently demonstrated by a citation of the ages attributed to certain of the primitive rulers. The inaugurative myth, Jimmu Tenno, is said to have lived 127 years; Koan, the sixth Mikado, 137 years; Nintoku, the seventeenth Mikado (D. 399 A.D.), 122 years; and it is not until the fifth century A.D. that the viability of the rulers appears to have become permanently limited to a reasonable degree. It is true that the birth and death of Jimmu are solemnised as national festivals, and that writers on such sober topics as the industrial arts do not hesitate to refer for their landmarks to periods long antedating the true historical period; but all allowance must be made for inherited credulity in ancient traditions, which here form part of a state religion and establish the very sanctity of the throne.

We are glad to see that Dr. Rein does not altogether reject the romantic episodes of Japanese history. Awaiting the advent of a native Walpole to bruise the simple faith of his countrymen with historic doubts, it is a grateful relief to the tedium of the long series of wars and court intrigues that form the burden of the rather monotonous recitative of the Oriental Clio, to dwell for a moment on such stories as those of the gentle wife of Yamato Dake, who cast herself into the sea to propitiate the angry gods that threatened the safety of her husband's ship; of Kesa, who sacrificed her life to preserve her wifely fidelity; and many others of the number that have lent inspiration to the pencils of Hokusai, Yosai, and a hundred lesser artists. They are probably no more apocryphal than many of the wearisome details through which the student of history must plod.

The title "Geschichte des Japanischen Volkes" adopted by the author is somewhat misplaced. The history is not that of the people but of their rulers, and it would have been well had the author given the section a better claim to the heading by interspersing the story of battle and murder by some account of the development of laws, literature, painting, the various industrial arts, and such important social ceremonies as those of the *Cha-no-yu*, which lose much of their significance when divorced from the general history of the empire.

The most valuable portion of the sketch to the foreign world is that relating to the pregnant events of the last twenty years. In the narration of occurrences which have compelled the foreign powers, and especially Great Britain, to join issue with the Japanese Government Dr. Rein displays an absence of partisanship quite novel to those experienced in the discussion of Anglo-Japanese politics. His review of the present position and future prospects of the nation is thoughtfully cautious, and while drawing attention to the recent educational studies and the many wise acts of the present Government, shows a dark reverse to the picture in the financial difficulties now threatening serious obstruction to the path of improvement. The question of the opening of new ports or of the entire country to foreign enterprise and capital is also considered, and the writer points out the deadlock created on the one side by the great disadvantages which the Japanese foresee in admitting to competition an infinitely stronger commercial race, over whose actions they can have no judicial control, and on the other by the inexpediency, from the foreigners' point of view, of a surrender of the treaty rights while the laws and means of administration in Japan are in so unsatisfactory a condition as at the present time.

In an interesting chapter upon the Ethnography of the Japanese the author takes up the vexed problem of the origin of the now dominant race, who displaced the aboriginal Ainos. He believes, from considerations of speech, physiognomy, and traditions that they are a branch of the old Altaic family, which spread from its birthplace in all directions over the continent of Asia, some reaching Japan *viâ* Tsushima, Iki, and Oki, others settling at various parts of the mainland to form the Korean, Mandschurian, and other kindred people. In this view he is supported to some extent by the physiognomical identity with the Japanese of the yet pure descendants of the Korean potters brought over as trophies of Taiko's victorious arms at the end of the sixteenth century, and established in the province of Satsuma. Mr. Aston's researches into the comparative philology of the Japanese and Korean languages (*Trans.* Royal Asiatic Society, 1879) tend to a similar conclusion, but leave the question still open.

The analyses of literature, language, and religion are necessarily incomplete, but awaiting the further progress of the labours of the scholars now engaged in the study of these special branches, Dr. Rein's summary of the present knowledge will be of great service.

The author's views as to the character of the Japanese as a race are neither romantically favourable, like those of the great majority of travellers, nor unjustly contemptuous, like the convictions cherished by nearly all settlers. The national defects Dr. Rein considers to be a greed for novelty and a lack of stability and perseverance; but although this verdict would appear to be sanctioned by recent experience, the history of the country really points to nothing less than instability. A blind admiration for antiquity and a persevering if not energetic industry has characterised nearly the whole of their older manufactures and artistic productions, and the many centuries of persistence in the path opened by their forefathers were terminated only by a sudden change of circumstances, and an entirely forced and unsought relationship with the outer world. They are now learning an entirely new exercise of their powers, and some clumsiness at the outset is inevitable, while the very impetuosity of their progression necessarily brings their faults more easily within the scope of a passing glance. They have now bought experience, and until the world sees how they can utilise their expensive purchase any judgment is premature. They have indeed two serious drawbacks, poverty of material resources, and a written language that isolates them from the European world, and imposes serious limitations upon the interchange of the higher order of ideas amongst themselves; but the present generation can scarcely be blamed for either evil. If there be a charge in the past and present to which they are fairly open it is defect of invention, for as their recent knowledge is taken from Europe, so in former times were they indebted to the Asiatic continent for literature, arts, religion, and laws, as well as for a thousand smaller traits of civilisation, some of which they have preserved longer or better than their teachers.

Whatever dispraise is laid upon the people, nearly all writers agree to credit them with remarkable cleanliness. Miss Bird, however, who has studied Japan under a new aspect, gives a different testimony as to the interior, and the few travellers who have caught a glimpse of the unbeaten tracks of the great cities might make strange revelations. As the better class European generally knows little or nothing of the secrets of his own metropolitan slums, it is conceivable that a foreigner living in Tokio may not be aware that it contains other habitations than those he passes in the public thoroughfares; but were curiosity or chance to lead him to thread some of the little, hardly noticeable, inlets which here and there break the line of the street dwellings he would be startled by the new world revealed to him—one where the hundreds of thousands of poor of the great city live, densely packed in filth and disease, in dilapidated dens with crumbling walls and roofs that would render needless the spell of Asmodeus to the Don Cleofas who cares to peer at the miseries only half concealed by the long lines of sheds, moated with foul stagnant drains, flanked by reeking accumulations of sewage and garbage, and cut off from ventilating breezes by the dwellings of the more fortunate but less numerous citizens. Had Dr. Rein extended his pilgrimage to the *Uradana* he would have written a new and curious chapter.

As regards bathing, it is certainly a common custom, but with the poorer classes it is far less frequent than travellers would lead us to believe. It is moreover not so much dictated by any unconquerable intolerance of dirt as by the combined attractions of warm water and neighbourly gossip. Whatever purification may be derived from the common use of a limited quantity of water by several dozens of people, it is doubtful whether we may not take as a set-off the odoriferous condition of the unwashed winter garments which often do unrelieved duty day and night for the whole season, and the very scant attention that the native feels impelled to bestow upon his hands and face in the intervals of his visits to the bathing-house. These remarks however do not imply that the working orders in Japan compare unfavourably in respect to physical purity with their European brethren.

The maps and illustrations are excellent in choice and execution. One error must however be indicated in the woodcut described as a "*Riu-kiu-Insulander*," which is really an accurate portrait of the Korean envoy who visited Japan in 1877.

It is impossible to do justice to Dr. Rein's important book in the space at our command. Its construction is eminently scientific, and its thoroughness will excite the admiration of all who know the difficulty of obtaining, and especially of selecting, information upon many of the matters so exhaustively treated. The errors are few and seldom important, and will probably disappear in the next edition. One powerful recommendation is the absence of the *ego* from its pages; the author everywhere studiously keeps his own individuality concealed, and in the discussion of most points he is nearly always contented with such a statement and grouping of the principal facts as will leave the inference well within the grasp of the reader's mind. In conclusion, it is the best of the many publications upon the subject of Japan that have appeared in the last ten years, and, unlike most of the number, supplies a real want, and will be received gratefully by all who seek for solid, trustworthy information. We trust that the completion of the work will soon be issued.

OUR BOOK SHELF

Études géométriques et cinématiques. Note sur quelques Questions de Géométrie et de Cinématique, et Réponse aux Réclamations de M. l'Abbé Aoust. Par E. J. Habich. 80 pp. (Lima, 1880.)

M. L'ABBÉ AOUST, author of the "Analyse infinitésimale des Courbes planes," and our author put forward conflicting claims as to priority of discovery.

The polemics have fired off their powder in *Les Mondes* (tome iv., 1880, Aoust: tome l., 1879, Habich; see also the *Comptes rendus*, lxxxv., 1877, and lxxxix., 1879), and the object of the present pamphlet is "de réduire à leur juste valeur les assertions" of the Abbé. The matters in dispute can be inferred from the three divisions of the present work:—

"1. Développoïdes—considérations historiques, étude des enveloppes des droites par la considération du centre instantané de rotation, développoïdes des divers ordres et devellopoïdes inverses.

"2. Coordonnées tangentielles-polaires.

"3. Mouvement géométrique d'une figure plane dans son plan—considérations générales, mouvement géométrique déterminé par deux systèmes d'enveloppées et d'enveloppes, mouvement d'une droit sur un plan."

We have, of course, but one side of the quarrel presented to us, but leaving polemics on one side there is a great deal of interesting matter put before us. Time will, no doubt, settle the question of priority.

A Synopsis of Elementary Results in Pure and Applied Mathematics. By G. S. Carr, B.A. Vol. i. part viii. (C. F. Hodgson and Son, 1880.)

WE recently noticed with approval the volume containing the first seven parts. This eighth part carries on the articles from 1400 to 1868, and is concerned with the differential calculus. It contains an abstract of the usual processes, and besides gives a succinct account of the theory of operations, and an analysis of matters which are treated of in the higher algebra, as Jacobians and quantics, and closes with maxima and minima, the geometrical applications being reserved for the parts on Co-ordinate Geometry.

These fifty-six pages are very correctly printed, at least we have not detected more than three or four trivial typographical errors.

This part maintains the handy character for reference of its forerunners.

The Practical Fisherman. By T. H. Keene. (London: *The Bazaar* Office.)

THIS book deals with the natural history, the legendary lore, and the capture of British freshwater fish, together with the art of tackle-making. The author has bestowed great care on his work, and seems to have studied every book written or published on the charming subject from Oppian to the present time. Mr. Keene is besides an enthusiastic fisherman, and has thus produced a treatise of great interest to the practical angler. We may add that this work is almost the only one on angling which treats of the natural as well as the traditional history of fishes.

LETTERS TO THE EDITOR

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

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

The Movements of Leaves

FRITZ MUELLER has sent me some additional observations on the movements of leaves, when exposed to a bright light. Such movements seem to be as well developed and as diversified under the bright sun of Brazil, as are the well-known sleep or nyctitropic movements of plants in all parts of the world. This result has interested me much, as I long doubted whether paraheliotropic movements were common enough to deserve to be separately designated. It is a remarkable fact that in certain species these movements closely resemble the sleep movements of allied forms. Thus the leaflets of one of the Brazilian Cassiæ assume when exposed to sunshine nearly the same position as those of the not distantly allied Hæmatoxylon when asleep, as shown in Fig. 153 of "The Movements of Plants." Whereas the leaflets of this Cassia sleep by moving down and rotating on their axes, in the same peculiar manner as in so many other species of the genus. Again, with an unnamed species of Phyllanthus, the leaves move forwards at night, so that their midribs then stand nearly parallel to the horizontal branches from which they spring; but when they are exposed to bright sunshine they rise up vertically, and their upper surfaces come into contact, as they are opposite. Now this is the position which the leaves of another species, namely *Phyllanthus compressus*, assume when they go to sleep at night. Fritz Müller states that the paraheliotropic movements of the leaves of a Mucuna, a large twining Papilionaceous plant, are strange and inexplicable; the leaflets sleep by hanging vertically down, but under bright sunshine the petiole rises vertically up, and the terminal leaflet rotates by means of its pulvinus through an angle of 180°, and thus its upper surface stands on the same side with the lower surfaces of the lateral leaflets. Fritz Müller adds, "I do not understand the meaning of this rotation of the terminal leaflet, as even without such a movement it would be apparently equally well protected against the rays of the sun. The leaflets, also, on many of the leaves on the same plant assume various other strange positions." With one species of Desmodium, presently to be mentioned as sleeping in a remarkable manner, the leaflets rise up vertically when exposed to bright sunshine, and the upper surfaces of the lateral leaflets are thus brought into contact. The leaves of *Bauhinia grandiflora* go to sleep at an unusually early hour in the evening, and in the manner described at p. 373 of "The Movements of Plants," namely, by the two halves of the same leaf rising up and coming into close contact: now the leaves of *Bauhinia Brasiliensis* do not sleep, as far as Fritz Müller has seen, but they are very sensitive to a bright light, and when thus exposed the two halves rise up and stand at 45° or upwards above the horizon.

Fritz Müller has sent me some cases, in addition to those given in my former letter of March 3, of the leaves of closely-allied plants which assume a vertical position at night by widely different movements; and these cases are of interest as indicating that sleep-movements have been acquired for a special purpose. We have just seen that of two species of Bauhinia the leaves of one sleep conspicuously, while those of a second species apparently do not sleep at all. The leaves of *Euphorbia jacquiniæflora* depend vertically at night, whereas those of a dwarfish Brazilian species rise vertically up at night. The leaves of this Euphorbia stand opposite one another—a position which is rather rare in the genus; and the rising movement may be of service to the plant, as the upper surfaces of the opposite leaves mutually protect one another by coming into contact. In the genus Sida the leaves of two species rise, while those of a third Brazilian species sink vertically down at night. Two species of Desmodium are common plants near Fritz Müller's house: in one the leaflets move simply downwards at night; but in the other not only do the three leaflets move vertically down, while the main petiole rises vertically up, as is likewise the case with *D. gyrans*, but in addition the lateral leaflets rotate so as to stand parallel with the terminal leaflet, behind which they are more or less completely hidden. This, as far as I have seen, is a new kind of nyctitropic movement; but it leads to a result common to several species, namely, that of packing the three leaflets closely together and placing them in a vertical position.

Down, Beckenham, Kent, April 14 CHARLES DARWIN

Spectrum of the Star Ll. 13412

THE spectrum of the star Ll. 13412 appears to be in some respects unique. It consists mainly of three bright lines having wave-lengths of 545, 486, and 466 millionths of a millimetre. Four other stars have hitherto been found whose spectra are of this character. Three of them are in Cygnus, and have lines whose wave-lengths are 580, 568, 536, and 467. The fourth star, Oeltzen 17681, has lines at about 582 and 470 (NATURE, vol. xxii. p. 483). The line or band at 467 appears to be common to all, and that at 580 to the last four. The line at 486 in Ll. 13412 coincides with the F line of hydrogen, but is not visible in the other stars. The line at 545 is also absent in them. This star therefore appears to resemble the others in kind, but not in the material of which it is composed. It is also much brighter than the others, so that it is not a difficult object with a small telescope. Its position for 1880 is in R.A. 6h. 49·3m. and Dec. $-23° 47'$. It is easily found as a seventh magnitude star about 15′ north of o′ *Canis Majoris*.

Cambridge, U.S., April 14 EDWARD C. PICKERING

The Indian Winter Rains

IN NATURE, vol. xxiii. p. 400, Mr. F. Chambers very properly points out that the winter rains of Northern India, though usually heaviest in years when the *mean* pressure is above the average, are yet coincident with short periods of low rather than of high pressure. The way in which Mr. Chambers accounts for the low pressure seems, however, rather far-fetched. It is true that on one or two of the American weather charts storm tracks are shown extending from the Mediterranean to Northern India or the Bay of Bengal, but these paths are drawn with dotted lines indicating that they are doubtful, and, considering the absence of meteorological stations in the greater part of the area between the Mediterranean and India, and the nature of the intervening country—especially Afghanistan with its high mountains—I should say the evidence upon the strength of which the American chartographer laid down these storm tracks, was of the slightest possible description. The winter rains are however accompanied by a cyclonic movement of the air over Northern India, and I wish to point out that, whether the cyclonic disturbance be a European or Transatlantic visitor, as Mr. Chambers supposes, or a native of the Indian region, generated by the rainfall, as Mr. Eliot has taught in his report for 1877, the "old notion" of the connection of the rains with the upper antimonsoon current is by no means exploded. The progress of the disturbance and of the rainfall is usually from north-west to south-east, and the rainfall is heaviest, as a rule, on the eastern side of the disturbance. The winds which bring the rainfall therefore come from some southerly quarter, and as northerly winds generally continue blowing in the extreme south of India at the time when these disturbances occur in the north, the southerly rainy winds must be derived from an upper current which descends in the anti-cyclone or region of high pressure in the centre and south of India, or in the zone between the south of India and the equator. Mr. Blanford's modification of his former views regarding the origin of these rains appears from his remarks and the accompanying charts in the Meteorological Report for 1878 to be merely that the indraught towards the region of precipitation is not confined to Northern India, but is occasionally, though rarely, felt as far south as Ceylon.

In a letter of mine that appeared in NATURE for the following week (p. 409), there was a mistaken inference from Mr. Blanford's investigation regarding the "Barometric See-saw" between India and West Siberia that I beg your permission to correct. The mean pressure at sea-level in the Indo-Malayan and West Siberian regions appears from Mr. Buchan's charts to be nearly the same both on the average of the year and in January and July. Also no wind blows directly from the one region to the other. We cannot therefore infer anything regarding the strength of the winds from Mr. Blanford's results, but we may regarding temperature. The proper inferences of this kind from the results arrived at by Mr. Blanford and Mr. Archibald appear to be these:—(1) The range of temperature in the 11-year period is greater in Siberia than in surrounding countries; (2) Siberia is coldest, compared with neighbouring countries, at times of maximum sun-spot; (3) This relation is most marked in winter; and (4) near the coasts of the Pacific (Nertchinsk, Pekin, Zi-ka-wei), the Indian (all the Indo-Malayan stations, especially those nearest the sea), and the Atlantic (London) oceans, where presumably the range of temperature is less than in the heart of the continent, the variation of the barometer in the 11-year period is opposite to that observed in Siberia. S. A. HILL

Allahabad, March 29

Palæolithic Man

IT is desirable that further search should be made for implements made by man in the deposits of this country assumed to be older than the well-known and accepted implementiferous river-gravels.

In the gravels belonging to the Thames, in and near London, palæolithic implements are of not infrequent occurrence. In my own collection I have more than 120 examples—with few exceptions found by myself—and I know of at least another hundred specimens found chiefly by London friends who have availed themselves of hints given by me.

My object now is to direct attention to the fact that the implements are not only found in and near London in the lower and middle terraces of gravel some 25 to 70 feet above the ordnance datum, but at far greater heights. Some of these heights near London may, and others no doubt do, belong to the Thames or to its tributaries, but they all (in different degrees) appear to point to a more remote time than the period when the lower terraces of the Thames and its tributaries were formed. Some of the implements now found in the lower gravels are clearly "derived" from more ancient deposits. For instance, I have one example white in colour and highly porcellaneous:—the white colour has been brought about by the decomposition of the flint in some ancient loam or clay, and not from the gravel in which the implement was found: this is proved by several more or less highly-polished accidental fractures at the edges of a different colour from the general white surface: these coloured fractures are more recent than the white facets, and date from the last deposition of the implement in the lower terrace: the white abraded flakings belong to a highly remote time. Dr. John Evans records the finding of an implement in the Thames gravel at Highbury, at 102 feet, whilst I have found one (also near Highbury), at an elevation of 144 feet. Last summer I found an implement on the eminence at the north of, and overlooking Ealing Dean, at a height of 164 feet. This is 72 feet higher than the implementiferous beds of Ealing Dean described by General Pitt Rivers, and between 80 and 100 feet higher (in one instance 104 feet higher) than the implement-bearing gravels at Acton described by the same gentleman. The gravel at the 164-feet elevation forms an isolated patch on the extreme top of a hill. I watched the excavations here (which were shallow) for road-making, with great care, and with the implement I found several flakes. These heights agree well with the heights of some of the implementiferous gravels found capping the cliffs in the South of England, also with the Erith position at Northumberland Heath, where Mr. F. C. J. Spurrell found an implement at an elevation of 175 feet.

Most geologists know the high gravels overlooking Hertford, Ware, and Amwell; their altitude is from 130 to over 180 feet above the ordnance datum. Gravel from the two first of these places is brought to London for ballast in thousands of tons. A year or two ago great quantities of gravel from Hertford were brought to Finsbury Park by the Great Northern Railway, and in the gravel thrown down near Finsbury Park I picked up a good sub-triangular wedge-shaped implement. Further search produced a second implement, a good trimmed flake, and a few simple flakes. The worked flints in the Hertford gravel are however so rare that the search for them is the most hopeless task conceivable. There is not more than one flake in 500 tons, not one implement in 5000 tons of gravel. The gravel from Ware is also brought to the east of London for ballast, and I happened last year to mention the fact of my discoveries to Mr. J. E. Greenhill, the Principal of a school near Hackney Downs. Mr. Greenhill at once not only searched himself, but set his pupils to look over the Ware gravel, then laid down in large quantities near Clapton, with the result that a lårge broken ovate implement was found and several flakes. I also found a large and heavy "slice" flake with numerous facets on its worked side in the same gravel. Mr. Greenhill's success caused me to look carefully over a similar lot of gravel from Ware, laid down near Victoria Park. In this I found a sub-triangular implement and three flakes. I have also found a large greatly abraded flake in the Amwell gravel at Amwell. Elsewhere in east and north-east London I have looked over thousands of tons of Hertford and Ware gravel without decisive result. A week or two ago, however, as my younger son was returning home through Finsbury Park, he picked up a good scraper-like implement in the gravel (presumably from Hertford), just thrown on to the road inside the park. On hearing of the discovery I at once went to Finsbury Park and looked carefully over all the recently thrown down material, but with no farther result. I have visited the different pits at Hertford, Ware, and Amwell several times, but there is never enough gravel exposed (considering the extreme comparative rarity of the implements and flakes) to give one a chance of finding an implement. I have found in the pits several simple flakes, with the cone of percussion, and that is all. At what depth the implements occur in the gravel I do not know, but that implements really do come out of the high gravels overlooking Hertford and Ware I think there can be no doubt. Reference was made by me to these implements at the Anthropological Institute three years ago, when two or three specimens were exhibited by me.

WORTHINGTON G. SMITH

125, Grosvenor Road, Highbury, N.

Sound of the Aurora

WITH every respect for the ability and acuteness of the late Sir John Franklin and his companions, I do not think it conclusive, as Mr. Rouse seems to do, that because they heard no sounds "with the aurora borealis" (NATURE, vol. xxiii. p. 556), no sounds are produced by it.

All Indians, both on the shores of Hudson's Bay and near Bear Lake, and the Eskimos on many parts of the coast, assert positively that the bright, varying, flickering,[1] and rapidly-moving auroræ do produce sound. The senses of hearing and smelling in the Indian and Eskimo are far more acute than in the civilised man; and both sounds and smells which to the latter are not perceptible are perfectly so to the more sensitive auditory and olfactory organs of the savage.

The theory that "the attractive force of the aurora is increased within a certain limit as its rays proceed southward" is scarcely borne out by my experience.

When wintering at Fort Hope, Repulse Bay, in 1846-47 and 1853-54, lat. 66° 32′ N., the result of my observations was, as far as I can discover, exactly similar to that of Parry in 1824-25 at Port Bowen in lat. 73° 15′ N., 400 miles further north and fifty miles west of Fort Hope: at both no effect was produced on the magnetic needle.

At Repulse Bay, and it may have been the same at Port Bowen, the character of the aurora was perfectly different from that generally seen at Great Bear Lake, which acted so powerfully on the needle, the former being almost always of a uniform pale yellow or straw colour, with little rapid motion, whereas the latter was generally flashing, flickering, rapidly moving, and of diverse hues.

One peculiarity of the auroræ observed at Repulse Bay may be worthy of notice: they were chiefly seen to the magnetic south—that is south 62° east true—usually in the form of an arch rather low down—and I may add that in that direction at a distance of thirty or forty miles from our head-quarters a large extent of sea is kept open all winter by strong currents. The Eskimos of Repulse Bay do not say much about the aurora beyond expressing a belief that it is the spirits of their dead visiting each other in the heavens.

It is probably a matter of little or no importance in a question of this kind, but Mr. Rouse has given the latitudes of the southern shores of Great Bear Lake from 90 to 200 miles too far north.

Fort Franklin, where Franklin made his chief observations, is situated in latitude 65° 12′ N. at the extreme south-west of Great Bear Lake, whereas Fort Confidence, where Sir J. Richardson and I made ours with like results, is at the extreme north-east of the lake in lat. 66° 54′ N., the stations being 150 miles distant from each other.

It is perhaps not being too sanguine to hope that in this period of marvellous discoveries, some instrument may be—if not already—invented, with the aid of which one may be able to decide the question satisfactorily as to whether the aurora in any form does or does not produce sound.

JOHN RAE

4, Addison Gardens, April 16

[1] I borrow this most appropriate term from Prof. Stokes, F.R.S., &c., of Cambridge.

THE SCIENTIFIC PRINCIPLES INVOLVED IN ELECTRIC LIGHTING[1]

II.

Lectures III. and IV.

ALL machines for the conversion of mechanical work into electricity are founded on Faraday's great discovery of the induced current derived from the relative motion of a magnet and a coil of wire. They are either continuous-current or alternate-current machines. From the continuous-current machines of Pixii in 1832 and Saxton and Clarke in 1835 and 1836, we pass to Wheatstone's introduction in 1845 of electromagnets in place of permanent magnets to produce the magnetic field. In 1854 Werner Siemens and Halske introduced the Siemens armature, in which the coil is wound longitudinally in a groove. In 1854 Hjorth patented an improved magneto-electric battery, in which the currents induced in the revolving armature pass round the electromagnets and produce the magnetic field. This is the principle of the dynamo-electric machine, which was afterwards rediscovered by Siemens and by Wheatstone simultaneously in 1867, when on the same evening their two papers were presented to the Royal Society.

Then followed the Gramme armature, in which coils of wire are wound in sections all in the same direction round a ring; each section, when a current is flowing through it, may be regarded as an electro-magnet, and its principle of action is clear at once from the principles of Arago and from Lenz's laws for induced currents.

In dynamo-electric machines the external work in the electric arc is proportional to the square of the current, and is also proportional to the number of turns of the armature per minute.

Any disturbance in the resistance of the arc reacts on the electro-magnet, altering the strength of the magnetic field, thereby increasing the disturbance; this is the great disadvantage of dynamo-electric machines as compared with magneto-electric machines, where the magnet is either a permanent magnet or is excited by means of a separate current. Wilde, in 1863, employed a separate continuous current machine to give a permanent magnetic field, and made the armature of the second machine to revolve in this magnetic field. In alternate-current machines there is no commutator for making the current continuous, but the currents from the coil are collected and sent through the external resistance in opposite directions for every half-turn of the armature. The Alliance magneto-electric machine was the first of these, which was converted by Holmes into a continuous-current machine, and was by him first used in 1858 to produce the electric light for lighthouse illumination. He afterwards again converted his machine into an alternate-

[1] By Prof. W. Grylls Adams, F.R.S. Continued from p. 582.

current machine by removing the commutator, thereby producing a very effective machine.

All theoretical determinations of the efficiency of machines are complicated by the retardation of magnetisation of the magnets, which necessitates a change of position of the commutator or brushes in the direction of the rotation of the armature. The practical determinations of efficiency which have been made show that from 86 to 88 per cent. of the energy communicated to a dynamo-machine is converted into electrical energy, and that from 44 to about 50 per cent. of the total work may be converted into useful work in the external circuit. Among the more recent continuous current machines are the Brush and the Bürgin machines, which promise to give good results.

At intervals during the lecture the room was lighted by various electric lamps, the peculiarities of each of which were explained. The Brockie lamp, lent by the British Electric Light Company, and served by one of their Gramme machines; the Siemens pendulum-lamp lent by Dr. Siemens, and the Crompton lamp lent by Mr. Crompton, were each tried in turn, and attention was drawn to the Siemens' differential lamp, the Brush lamp, and other lamps and electric candles which were also exhibited.

The subject of the fourth Cantor lecture was the subdivision of the electric current and lighting by incandescence. Prof. Adams showed that objections raised to the electric light were similar to those which had been urged with regard to gas when it was first introduced. He then compared the energy of Grove's cells with the energy derived from a small Gramme machine, and showed how impracticable it was to attempt to do by means of batteries the work which can be done by such machines. He then explained how the same amount of energy might be spent in two classes of machines, those of low internal resistance and low electromotive force which send a strong current through small external resistance, or quantity machines, and those of high internal resistance and high electromotive force sending a smaller current through large external resistance, or tension-machines. For very high resistances the discharge of an induction-coil is taken, the action of which was compared to the action of the hydraulic ram. Prof. Adams proceeded to describe the Werdermann and the Joel lamps, and explained the kind of machine specially suited for such lamps, and regretted that it would not be possible to show them to the best advantage, or to give them a fair trial, because the machine actually in use at the speed at which it was running was not adapted for them. An electromotive force of 130 volts will send 50 webers through 10 lamps in series, and give an illumination of 320 candles in each lamp for an expenditure about 10 h.p. Taking Mr. A. Siemens' facts as to the cost, it appears that the electric light from the Joel lamp would be as cheap as gas at the rate of 2*s.* per 1000 cubic feet. The laws of the subdivision of the electric current were discussed, and their application to the system of incandescent lighting adopted by Swan, and by Lane-Fox and Edison was clearly shown. With the Bürgin machine, then in use, giving at 1620 revolutions a minute an electromotive force of 160 volts, and a current of 24 webers through an external resistance of about 7 ohms, it was shown that 24 rows of two Swan lamps in series or 48 lamps could be lit up: each lamp being of 80 ohms resistance, and giving a 48 candle-power light. If the resistance of each lamp be 40 instead of 80 ohms, then double the number of lamps might be taken in series, giving about 100 lamps from the machine.

With the Brush machine at least 140 lamps might be lit up in 10 parallel rows of 14 lamps in series. The early attempts of King, and Staite, and Konn to light by incandescence were then explained, and experiments made to illustrate the phenomena seen in high vacua, such as are necessary to enable Mr. Swan and Mr. Lane Fox to preserve their carbons from wasting when rendered incandescent by means of the electric current.

The room was well lighted by means of 20 Swan lamps, each giving a pleasant and steady light of about 40 or 50 candle-power, the lamps being arranged in 10 rows of two in series. Two table-lamps were placed on the lecture-table, which could be put out separately or made to glow at pleasure, and these lamps could be lifted off their stands and others put in their places without disturbing other lights which were arranged in multiple arc and worked from the same dynamo-machine.

THE FRENCH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE AT ALGIERS[1]

II.

Algiers, April 17

ON Friday afternoon various papers on local subjects were read to a general audience in the *foyer* of the theatre. They related to the geology, geography, and demography of Algeria, but the most interesting paper was by our Consul-General, Col. Playfair, on a visit to the country of the Kroumirs—interesting not only because the aggressions of this tribe have led to the present complications in Tunis, which will probably end in war, but also because Col. Playfair and Lord Kingston are the only Europeans who have visited their country. They inhabit the district near Le Calle, that is to say, the northern portion of the boundary between Algeria and Tunis, and they only nominally acknowledge the suzerainty of the Bey of Tunis.

On Friday evening a discourse was delivered in the theatre "On Paludisme from a Surgical Point of View." It was of such a very technical character that many members of the Association did not attend. In fact the Congress is to a great extent medical. While the Physical and Botanical Sections are positively languishing for want of papers, and will probably come to a premature ending on Monday, the papers waiting to be read before the Medical Section fill two pages of yesterday's programme.

More activity was manifested in the sectional work on the second day of the Congress; the papers in most of the sections were more numerous and the audiences larger. The physical section is the most neglected of all. Long after the proper time of commencement the president had not made his appearance, and at length Mr. Siemens, the only honorary vice-president, was requested to take the chair. Of the four papers read three were by Englishmen, and on the first day of meeting one paper alone was read by a Dutchman. Pure physics in France is unfortunately quite unrepresented at the Congress. In the Chemical Section M. Baunhauer read a paper "On the Crystallisation of the Diamond," and M. de Foreland "On a New Apparatus for Gas Analysis." There were several good papers on meteorological subjects. Only three papers were read in the Geological Section, the most important of these by M. Villanova, "On the Unification of Geological Nomenclature." The Anthropological Section was well attended, and papers of considerable local interest were read. The Sections of Geography and Political Economy mainly discussed the Sahara—on the one hand its physical geography, and on the other its colonisation.

In the Agricultural Exhibition one of the most interesting machines is the solar engine, the boiler of which is placed in the axis of a mirror 14 feet in diameter, and formed of three portions of hollow truncated cones, so as to get a close approximation to the parabola. When the sun shines a pressure of from three to four atmospheres is produced in the boiler, and a force of one-horse power is produced through the intervention of an

[1] Continued from p. 583.

ordinary steam-engine. The mirror is of silvered copper; the boiler is blackened and is surrounded by a glass cylinder, which of course permits the passage of the sun's heat through it, but obstructs its escape after absorption. The whole thing costs 4000 francs, and it could be used in many countries for at least 200 days in the year.

G. F. RODWELL

THE HERRING [1]

IT is now nineteen years since my attention was first specially directed to the natural history of the herring, and to the many important economical and legal questions connected with the herring fisheries. As a member of two successive Royal Commissions, it fell to my lot to take part in inquiries held at every important fishing station in the United Kingdom between the years 1862 and 1865, and to hear all that practical fishermen had to tell about the matter; while I had free access to the official records of the Fishery Boards. Nor did I neglect such opportunities as presented themselves of studying the fish itself, and of determining the scientific value of the terms by which, in the language of fishermen, the various conditions of the herring are distinguished.

Diligent sifting of the body of evidence thus collected and passed under review, led to the satisfactory clearing away in my own mind of some of the obscurities which, at that time, surrounded the natural history of the fish. But many problems remained, the solution of which was not practicable by investigations which, after all, were only incidents in the course of a large inquiry, embracing a vast number of topics beside herrings and herring fisheries; and it is only within the last few years that the labours of the German West Baltic Fishery Commission have made such large additions to the state of our knowledge in 1865, that the history of the herring is brought within measurable distance of completeness.

Considering the vast importance of the herring fisheries of the Eastern Counties, it occurred to me when the President of the National Fishery Exhibition did me the honour to ask me to address you, that nothing could be more likely to interest my audience than a summary statement of what is now really known about a fish which, from a fisherman's point of view, is probably the chief of fishes.

I am aware that I may lay myself open to the application of the proverb about carrying coals to Newcastle, if I commence my observations with a description of the most important distinctive characters of a fish which is so familiar to the majority of my hearers. And perhaps it is as well that I should at once express my belief that most of you are as little likely to mistake a herring for anything else as I am. Nay, I will go further. I have reason to believe that any herring-merchant, in a large way of business, who may be here, knows these fish so much better than I do, that he is able to discriminate a Yarmouth herring from a Scotch herring and both from a Norway herring; a feat which I could not undertake to perform. But then it is possible that I may know some things that he does not. He is very unlike other fishermen and fish-merchants with whom I have met, if he has any but the vaguest notions of the way of life of the fish; or if he has heard anything about those singularities of its organisation which perplex biologists; or if he can say exactly how and why he knows that a herring is not a sprat, a shad, or a pilchard. And all kinds of real knowledge and insight into the facts of nature do so bear upon one another and turn out in strange ways practically helpful, that I propose to pour out my scientific budget, in the hope that something more may come of it than the gratification of intelligent curiosity.

If any one wants to exemplify the meaning of the word "fish" he cannot choose a better animal than a herring. The body, tapering to each end, is covered with thin, flexible scales, which are very easily rubbed off. The taper head, with its underhung jaw, is smooth and scaleless on the top; the large eye is partly covered by two folds of transparent skin, like eyelids—only immovable and with the slit between them vertical instead of horizontal; the cleft behind the gill cover is very wide, and, when the cover is raised, the large red gills which lie beneath it are freely exposed. The rounded back bears the single moderately long dorsal fin about its middle. The tail fin is deeply cleft, and on careful inspection small scales are seen to be continued from the body, on to both its upper and its lower lobes, but there is no longitudinal scaly fold on either of these. The belly comes to an edge, covered by a series of sharply-keeled bony shields between the throat and the vent; and behind the last is the anal fin, which is of the same length as the dorsal fin. There is a pair of fore-limbs, or pectoral fins, just behind the head; and a pair of hind-limbs, or ventral fins, are situated beneath the dorsal fin, a little behind a vertical line drawn from its front edge, and a long way in front of the vent. These fins have bony supports or rays, all of which are soft and jointed.

Like most fishes, the herring is propelled chiefly by the sculling action of the tail-fin, the rest serving chiefly to preserve the balance of the body, and to keep it from turning over, as it would do if left to itself, the back being the heaviest part of the fish.

The mouth of the herring is not very large, the gape extending back only to beneath the middle of the eye, and the teeth on the upper and lower jaws are so small as to be hardly visible. Moreover, when a live herring opens its mouth, or when the lower jaw of a dead herring is depressed artificially, the upper jaw, instead of remaining fixed and stationary, travels downwards and forwards in such a manner as to guard the sides of the gape. This movement is the result of a curious mechanical arrangement by which the lower jaw pulls upon the upper, and I suspect that it is useful in guarding the sides of the gape when the fish gulps the small living prey upon which it feeds.

The only conspicuous teeth, and they are very small, are disposed in an elongated patch upon the tongue, and in another such patch, opposite to these, on the fore part of the roof of the mouth. The latter are attached to a bone called the vomer, and are hence termed vomerine teeth. But, if the mouth of a herring is opened widely, there will be seen, on each side, a great number of fine, long, bristle-like processes, the pointed ends of which project forwards. These are what are termed the gill rakers, inasmuch as they are fixed, like the teeth of a rake, to the inner sides of those arches of bone on the outer sides of which the gills are fixed. The sides of the throat of a herring, in fact, are as it were cut by four deep and wide clefts which are separated by these gill arches, and the water which the fish constantly gulps in by the mouth flows through these clefts, over the gills and out beneath the gill covers, aërating the blood, and thus effecting respiration, as it goes. But since it would be highly inconvenient, and indeed injurious, were the food to slip out in the same way, these gill rakers play the part of a fine sieve, which lets the water strain off, while it keeps the food in. The gill rakers of the front arches are much longer than those of the hinder arches, and as each is stiffened by a thread of bone developed in its interior, while, at the same time, its sides are beset with fine sharp teeth, like thorns on a brier, I suspect that they play some part in crushing the life out of the small animals on which the herrings prey.

Between these arches there is, in the middle line, an opening which leads into the gullet. This passes back into a curious conical sac which is commonly termed the stomach, but which has more the character of a crop.

[1] A lecture delivered by Prof. Huxley at the National Fishery Exhibition, Norwich, April 21, 1881.

Coming off from the under side of the sac and communicating with it by a narrow opening, there is an elongated tubular organ, the walls of which are so thick and muscular that it might almost be compared to a gizzard. It is directed forwards, and opens by a narrow prominent aperture into the intestine, which runs straight back to the vent. Attached to the commencement of the intestine, there is a score or more of larger and shorter tubular organs which are called the pyloric cæca. These open into the intestine, and their apertures may be seen on one side of it, occupying an oval space, in the middle of which they are arranged three in a row.

The chief food of the herring consists of minute Crustacea, some of them allied to the shrimps and prawns, but the majority belonging to the same division as the common *Cyclops* of our fresh waters. These tenant many parts of the ocean in such prodigious masses that the water is discoloured by them for miles together, and every sweep of a fine net brings up its tens of thousands.

Everybody must have noticed the silvery air-bladder of the herring, which lies immediately under the backbone, and stretches from close to the head to very near the vent, being wide in the middle and tapering off to each end. In its natural state, it is distended with air; and, if it is pricked, the elastic wall shrinks and drives the air out, as if it were an indiarubber ball. When the connexions of this air-bladder are fully explored it turns out to be one of the most curious parts of the organisation of the whole animal.

In the first place, the pointed end of the sac or crop into which the gullet is continued runs back into a very slender duct which turns upwards and eventually opens into the middle of the air-bladder. The canal of this duct is so very small and irregularly twisted, that, even if the air-bladder is squeezed, the air does not escape into the sac. But, if air is forced into the sac by means of a blowpipe, the air passes without much difficulty the other way, and the air-bladder becomes fully distended. When the pressure is removed, however, the air-bladder diminishes in size to a certain extent, showing that the air escapes somewhere. And if the blowing up of the air-bladder is performed while the fish is under water, a fine stream of air-bubbles may be seen to escape close to the vent. Careful anatomical investigation, in fact, shows that the air-bladder does not really end at the point where its silvery coat finishes, but that a delicate tube is continued thence to the left side of the vent, and there ends by an opening of its own.

Now the air-bladder of all fishes is, to begin with, an outgrowth from the front part of the alimentary canal, and there are a great many fishes in which, as in the herring, it remains throughout life in permanent communication with the gullet. But it is rare to find the duct so far back as in the herring; and, at present, I am not aware that the air-bladder opens externally in any fishes except the herring and a few of its allies.

There is a general agreement among fishermen that herrings sometimes make a squeaking noise when they are freshly taken out of the water. I have never heard this sound myself, but there is so much concurrent testimony to the fact that I do not doubt it; and it occurs to me that it may be produced when the herrings are quickly brought up from some depth by means of this arrangement. For under these circumstances the air, which the air-bladder contains, expands to such a degree, on being relieved from the pressure of the water, that deep-sea fishes with a closed air-bladder which are brought to the surface rapidly are sometimes fairly turned inside out by the immense distension, or even bursting, of the air-bladder. If the same thing should happen to the herring the like misfortune would not befall it, for the air would be forced out of the opening in question, and might readily enough produce the squeak which is reported. The common Loach[1] is said to produce a piping sound by expelling the air which this fish takes into its intestine for respiratory purposes.

At the opposite end of the air-bladder there is an even more curious arrangement. The silvery coat of the air-bladder ends in front just behind the head. But the air-bladder itself does not terminate here. Two very fine canals, each of which is not more than a two-hundredth of an inch in diameter, though it is surrounded by a relatively thick wall of cartilage, pass forward, one on each side, from the air-bladder to the back of the skull. The canals enter the walls of the skull, and then each divides into two branches. Finally, each of these two dilates into a bag which lies in a spheroidal chamber of corresponding size and form; and, in consequence of the air which they contain, these bags may be seen readily enough shining through the side walls of the skull, the bone of which has a peculiar structure where it surrounds them. Now these two bags, which constitute the termination of the air-bladder on each side, are in close relation with the organ of hearing. Indeed, a process of that organ projects into the front chamber on each side, and is separated by only a very delicate partition from the terminal sac of the air-bladder. Any vibrations of the air in these sacs, or any change in the pressure of the air in them, must thus tell upon the hearing apparatus.

There is no doubt about the existence of these structures which, together with the posterior opening of the air-bladder, were most accurately described, more than sixty years ago, by the eminent anatomist Weber, but I am afraid we are not much wiser regarding their meaning than we were when they were first made known. In fishes in general, there can be little doubt that the chief use of the air-bladder is to diminish the specific gravity of the fish and, by rendering its body of nearly the same weight as so much water, to render the business of swimming easier. In those fishes in which the passage of communication between the air-bladder and the alimentary canal is closed, the air is no doubt secreted into the air-bladder by its vessels, which are often very abundant. In the herring, the vessels of the air-bladder are very scanty; and it seems probable that the air is swallowed and forced into the air-bladder just as the loach swallows air and drives it into its intestine. And, as I have already suggested, it may be that the narrow posterior canal which leads from the air-bladder to the exterior is a sort of safety-valve allowing the air to escape, when the fish, rapidly ascending or descending, alters the pressure of the water upon the contained air.

This hypothesis may be put forward with some show of probability, but I really find it difficult to suggest anything with respect to the physiological meaning of the connection between the air-bladder and the ear. Nevertheless such an elaborate apparatus must have some physiological importance; and, this conclusion is strengthened by the well-known fact that there are a great many fishes in which the air-bladder and the ear become connected in one way or another. In the carp tribe, for example, the front end of the air-bladder is connected by a series of little bones with the organ of hearing, which is, as it were, prolonged backwards to meet these bones in the hinder end of the skull. But here, the air-bladder, which is very large, may act as a resonator; while, in the herring, the extreme narrowness of the passages which connect the air-bladder with the ear renders it difficult to suppose that the organ can have any such function.

In addition to the singular connection of the ear with the exterior by the roundabout way of the air-bladder, there are membranous spaces in the walls of the skull by which vibrations can more directly reach the herring's ear. And there is no doubt that the fish is very sensitive

[1] See Müller, "Ueber Fische welche Töne von sich geben," *Archiv für Physiologie*, 1857, p. 267. The herring is not mentioned in Müller's list of vocal fishes.

to such vibrations. In a dark night, when the water is phosphorescent or, as the fishermen say, there is plenty of "merefire," it is a curious spectacle to watch the effect of sharply tapping the side of the boat as it passes over a shoal. The herrings scatter in all directions, leaving streaks of light behind them, like shooting stars.

The herring, like other fishes, breathes by means of the gills—the essential part of which consists of the delicate, highly-vascular filaments, which are set in a double row on the outer faces of each of the gill arches. The venous blood which returns from all parts of the body to be collected in the heart, is pumped thence into the gills, and there exchanges its excess of carbonic acid gas for the gaseous oxygen which is dissolved in sea-water. The freedom of passage of the water, and the great size and delicacy of the gills, facilitate respiration when the fish is in its native element; but the same peculiarities permitting of the rapid drying and coherence of the gills, and thus bringing on speedy suffocation, render its tenure of life, after removal from the water, as short as that of any fish. It may be observed, in passing, that the wide clefts behind the gill-covers of the herring have some practical importance, as the fish, thrusting its head through the meshes of the drift-net, is caught behind them and cannot extricate itself. In the herring, the upper end of the last gill cleft is not developed into a sac or pouch, such as we shall find in some of its near neighbours.

The only other organs of the herring, which need be mentioned at present, are the milt and roe, found in the male and female herring respectively.

These are elongated organs attached beneath the air-bladder, which lie, one on each side of the abdominal cavity, and open behind the vent by an aperture common to the two. The spermatic fluid of the male is developed in the milt and the eggs of the female in the roe. These eggs, when fully formed, measure from one-sixteenth to one-twenty-fifth of an inch in diameter; and, as, in the ripe female, the two roes or ovaries stretch from one end of the abdominal cavity to the other, occupying all the space left by the other organs, and distending the cavity, the number of eggs which they contain must be very great. Probably 10,000 is an under-estimate of the number of ripe eggs shed in spawning by a moderate-sized female herring. But I think it is safer than the 30,000 of some estimates, which appear to me to be made in forgetfulness of the very simple anatomical considerations that the roe consists of an extensive vascular framework as well as of eggs; and, moreover, that a vast number of the eggs which it contains remain immature, and are not shed at the time of spawning.

In this brief account of the structure of the herring I have touched only on those points which are peculiarly interesting, or which bear upon what I shall have to say by and by. An exhaustive study of the fish from this point of view alone would require a whole course of lectures to itself.

The herring is a member of a very large group of fishes spread over all parts of the world, and termed that of the *Clupeidæ*, after *Clupea*, the generic name of the herring itself. Our herring, the *Clupea harengus*, inhabits the White Sea and perhaps some parts of the Arctic Ocean, the temperate and colder parts of the Atlantic, the North Sea, and the Baltic, and there is a very similar, if not identical, species in the North Pacific. But it is not known to occur in the seas of southern Europe, nor in any part of the intertropical ocean, nor in the southern hemisphere.

There are four British fishes which so closely resemble herrings, externally and internally, that, though practical men may not be in any danger of confounding them, scientific zoologists have not always succeeded in defining their differences. These are the Sprat, the Allice and Twaite Shads, and the Pilchard.

The sprat comes nearest; indeed young herrings and sprats have often been confounded together, and doubts have been thrown on the specific distinctness of the two. Yet if a sprat and a young herring of the same size are placed side by side, even their external differences leave no doubt of their distinctness. The sprat's lower jaw is shorter; the shields in the middle of the belly have a sharper keel, whence the ventral edge is more like a saw; and the ventral fin lies vertically under the front edge of the dorsal fin, or even in front of it; while in the herring, though the position of the ventral fin varies a little, it lies more or less behind the front margin of the dorsal fin. The anal fin is of the same length as the dorsal, in the herring, longer than the dorsal in the sprat. But the best marks of distinction are the absence of vomerine teeth in the sprat, and the smaller number of pyloric cæca, which do not exceed nine, their openings being disposed in a single longitudinal series.

Shads and pilchards have a common character by which they are very easily distinguished from both sprat and herring. There is a horizontal fold of scaly skin on each side of the tail above and below the middle line. Moreover they have no teeth in the inside of the mouth, and their pyloric cæca are very numerous—a hundred or more—their openings being disposed five or six in a row.

The shads have a deep narrow notch in the middle line of the upper jaw, which is absent in the pilchard. The intestine of the shad is short and straight, like that of the herring; while that of the pilchard is long and folded several times upon itself.

Both of these fishes, again, possess a very curious structure, termed an accessory branchial organ, which is found more highly developed in other fishes of the herring family, and attains its greatest development in a fresh-water fish, the *Heterotis*, which inhabits the Nile. This organ is very rudimentary in the shad (in which it was discovered by Gegenbaur[1]), but it is much larger in the pilchard, in which, so far as I know, it has not heretofore been noticed. In *Chanos* and several other Clupeoid fishes it becomes coiled upon itself, and in *Heterotis* the coiled organ makes many turns. The organ is commonly supposed to be respiratory in function; but this is very doubtful.

Herrings which have attained maturity and are distended by the greatly enlarged milt or roe are ready to shed the contents of these organs or, as it is said to spawn. In 1862, we found a great diversity of opinion prevailed as to the time at which this operation takes place, and we took a great deal of trouble to settle the question, with the result which is thus stated in our Report:—

"We have obtained a very large body of valuable evidence on this subject, derived partly from the examination of fishermen and of others conversant with the herring fishery; partly from the inspection of the accurate records kept by the fishery officers at different stations, and partly from other sources; and our clear conclusion from all this evidence is, that the herring spawns at two seasons of the year, in the spring and in the autumn. We have hitherto met with no case of full or spawning herrings being found, in any locality, during what may be termed the solstitial months, namely June and December; and it would appear that such herrings are never (or very rarely) taken in May or the early part of July, in the latter part of November, or the early part of January. But a spring spawning certainly occurs in the latter part of January, in February, in March, and in April; and an autumn spawning in the latter part of July, in August, September, October, and even as late as November. Taking all parts of the British coast together, February and March are the great months for the spring spawning, and August and September for the autumn spawning. It is not at all likely that the same fish spawn twice in the year; on the contrary, the spring and the autumn shoals are probably perfectly distinct; and if the herring, according to the hypothesis advanced above, come to maturity

[1] "Ueber das Kopfskelet von *Alepocephalus rostratus*," *Morphologisches Jahrbuch*, Bd. iv., Suppl. 1878.

in a year, the shoals of each spawning season would be the fry of the twelvemonth before. However, no direct evidence can be adduced in favour of this supposition, and it would be extremely difficult to obtain such evidence."[1]

I believe that these conclusions, confirmatory of those of previous careful observers[2] are fully supported by all the evidence which has been collected, and the fact that this species of fish has two spawning seasons, one in the hottest and one in the coldest months of the year, is very curious.

Another singular circumstance connected with the spawning of the herring is the great variety of the conditions, apart from temperature, to which the fish adapts itself in performing this function. On our own coasts, herrings spawn in water of from ten to twenty fathoms, and even at greater depths, and in a sea of full oceanic saltness. Nevertheless herrings spawn just as freely, not only in the narrows of the Baltic, such as the Great Belt, in which the water is not half as salt as it is in the North Sea and in the Atlantic, but even in such long inlets as the Schlei in Schleswig, the water of which is quite drinkable and is inhabited by freshwater fish. Here the herrings deposit their eggs in two or three feet of water; and they are found, along with the eggs of freshwater fish, sticking in abundance to such fresh-water plants as *Potamogeton*.

Nature seems thus to offer us a hint as to the way in which a fish like the shad, which is so closely allied to the herring, has acquired the habit of ascending rivers to deposit its eggs in purely fresh water.

If a full female herring is gently squeezed over a vessel of sea-water, the eggs will rapidly pour out and sink to the bottom, to which they immediately adhere with so much tenacity that, in half an hour, the vessel may be inverted without their dropping out. When spawning takes places naturally the eggs fall to the bottom and attach themselves in a similar fashion. But, at this time, the assembled fish dart wildly about, and the water becomes cloudy with the shed fluid of the milt. The eggs thus become fecundated as they fall, and the development of the young within the ova sticking to the bottom commences at once.

The first definite and conclusive evidence as to the manner in which herring spawn is attached and becomes developed that I know of, was obtained by Prof. Allman and Dr. MacBain in 1862,[3] in the Firth of Forth. By dredging in localities in which spent herring were observed on the 1st of March, Professor Allman brought up spawn in abundance at a depth of fourteen to twenty-one fathoms. It was deposited on the surface of the stones, shingle, and gravel, and on old shells and coarse shell-sand, and even on the shells of small living crabs and other crustacea, adhering tenaciously to whatever it had fallen on. No spawn was found in any other part of the Forth; but it continued to be abundant on both the east and the west sides of the Isle of May up to the 13th of March, at which time the incubation of the ovum was found to be completed in a great portion of the spawn, and the embryos had become free. On the 25th scarcely a trace of spawn could be detected, and nearly the whole of the adult fish had left the Forth.

Prof. Allman draws attention to the fact "that the deposit of spawn, as evidenced by the appearance of spent herrings, did not take place till about sixty-five days after the appearance of the herring in the Firth," and arrives at the conclusion that "the incubation probably continues during a period of between twenty-five to thirty days," adding however that the estimate must for the present be regarded as only approximative. It was on this and other evidence that we based our conclusion that the eggs of the herring "are hatched in at most from two to three weeks after deposition."

Within the last few years a clear light has been thrown upon this question by the labours of the West Baltic Fishery Commission, to which I have so often had occasion to refer.[1] It has been found that artificial fecundation is easily practised, and that the young fish may be kept in aquaria for as long as five months. Thus, a great body of accurate information, some of it of a very unexpected character, has been obtained respecting the development of the eggs, and the early condition of the young herring.

It turns out that, as is the case with other fishes, the period of incubation is closely dependent upon warmth. When the water has a temperature of 53° Fahrenheit, the eggs of the herring hatch in from 6—8 days; the average being seven days. And this is a very interesting fact when we bear in mind the conclusion to which the inquiries of the Dutch meteorologists, and, more lately, those of the Scottish Meteorological Society appear to tend, namely, that the shoals prefer water of about 55°. At 50° Fahrenheit, the period of incubation is lengthened to eleven days; at 46° to fifteen days; and at 38° it lasts forty days. As the Forth is usually tolerably cool in the month of March, it is probable that Prof. Allman's estimate comes very near the truth for the particular case which he investigated.

The young, when they emerge from the egg, are from one-fifth to one-third of an inch in length, and so extremely unlike the adult herring that they may properly be termed larvæ. They have enormous eyes and an exceedingly slender body, with a yelk bag protruding from its forepart. The skeleton is in a very rudimentary condition; there are no ventral fins; and instead of separate dorsal, caudal, and anal fins, there is one continuous fin extending from the head along the back, round the tail, and then forwards to the yelk bag. The intestine is a simple tube, ciliated internally; there is no air-bladder, and no branchiæ are yet developed. The heart is a mere contractile vessel, and the blood is a clear fluid without corpuscles. At first the larvæ do not feed, but merely grow at the expense of the yelk, which gradually diminishes.

Within three or four days after hatching, the length has increased by about half the original dimensions, the yelk has disappeared, the cartilaginous skeleton appears, and the heart becomes divided into its chambers; but the young fish attains nearly double its first length before blood corpuscles are visible.

By the time the larva is two-thirds of an inch long (a length which it attains one month after hatching), the primitive median fin is separated into dorsal, caudal, and anal divisions, but the ventral fins have not appeared. About this period the young animal begins to feed on small crustacea; and it grows so rapidly that, at two months, it is 1¼ inch long, and, at three months, has attained a length of about two inches.

Nearly up to this stage the elongated scaleless little fish retains its larval proportions; but, in the latter part of the third month, the body rapidly deepens, the scales begin to appear, and the larva passes into the "imago" state —that is, assumes the form and proportions of the adult, though it is not more than two inches long. After this, it goes on growing at the same rate (11 millimetres, or nearly half an inch) per month, so that, at six months old, it is as large as a moderate-sized sprat.

The well-known "whitebait" of the Thames consists,

[1] "Report of the Royal Commission on the operation of the Acts relating to Trawling for Herrings on the Coast of Scotland (1863)," p. 28.

[2] Brandt and Ratzeburg, for example, in 1833 strongly asserted that the herring has two spawning seasons.

[3] "Report of the Royal Commission on the Operation of the Acts relating to Trawling for Herring on the Coast of Scotland, 1863."

[1] See the four valuable memoirs, Kupffer, "Ueber Laichen und Entwickelung des Herings in der westlichen Ostsee"; *Idem*, "Die Entwickelung des Herings im Ei"; Meyer, "Beobachtungen über den Wachsthum des Herings"; Heincke, "Die Varietäten des Herings," which are contained in the *Jahresbericht der Commission in Kiel für* 1874-75-76—1878. Widegren's essay "On the Herring," 1871, translated from the Danish in U.S. Commission Reports, 1873—75, also contains important information.

so far as I have seen, almost exclusively of herrings, under six months old, and as the average size of whitebait increases, from March and April onwards, until they become suspiciously like sprats in the late summer, it may be concluded that they are the progeny of herrings which spawned, early in the year, in the neighbourhood of the estuary of the Thames, up which these dainty little fish have wandered. Whether it is the general habit of young herring, even of those which are spawned in deep water, to migrate into the shallow parts of the sea, or even into completely fresh waters, when such are accessible, is unknown.

In the Report on Trawling (1863) we observe :—

"It is extremely difficult to obtain any satisfactory evidence as to the length of time which the herring requires to pass from the embryonic to the adult or *full* condition. Of the fishermen who gave any opinion on this subject, some considered that a herring takes three, and others that it requires seven, years to attain the full or spawning condition; others frankly admitted that they knew nothing about the matter; and it was not difficult, by a little cross-examination, to satisfy ourselves that they were all really in this condition, however strongly they might hold by their triennial or septennial theories. Mr. Yarrell and Mr. Mitchell suppose with more reason that herring attain to full size and maturity in about eighteen months.

"It does not appear, however, that there is any good evidence against the supposition that the herring reaches its spawning condition in one year. There is much reason to believe that the eggs are hatched in, at most, from two to three weeks after deposition, and that in six to seven weeks more (that is at most ten weeks from the time of laying the eggs) the young have attained three inches in length. Now it has been ascertained that a young smolt may leave a river and return to it again in a couple of months increased in bulk eight or tenfold, and as a herring lives on very much the same food as a smolt, it appears possible that it should increase in the same rapid ratio. Under these circumstances nine months would be ample time for it to enlarge from three to ten or eleven inches in length. It may be fairly argued, however, that it is not very safe to reason analogically from the rate of growth of one species of fish to that of another; and it may be well to leave the question whether the herring attains its maturity in twelve, fifteen, or sixteen months open, in the tolerably firm assurance that the period last named is the maximum."

On comparing these conclusions with the results of the careful observations of the Baltic Commissioners, it appears that we somewhat over-estimated the rate of growth of the young herring, and that the view taken by Yarrell and Mitchell is more nearly correct. For supposing that the rate of growth after six months continues the same as before, a herring twelve months old will be nearly six inches long, and at eighteen months eight or nine inches. But full herrings may be met with little more than seven inches long, and they are very commonly found not more than nine inches in length.[1]

Fishermen distinguish four states of the herring. Fry or sile, when not larger than sprats; maties, when larger than this, with undeveloped roe or milt; full fish, with largely developed roe or milt; and spent or shotten fish, which have recently spawned.

Herring fry of the size of sprats are distinguished from full fish not merely by their size, but in addition, by the very slight development of the milt or roe, and by the accumulation of fat in the abdominal cavity. Bands of fat are found in the mesentery alongside the intestine, and filling up the interspaces between the pyloric cæca.

[1] Ljungman ("Preliminary Report on Herrings and Herring Fisheries on the West Coast of Sweden," translated in U.S. Commision Report, 1873-5) speaks of full herrings ready to spawn only 100-110 mm. (4 to 4½ in.) long, as observed by himself.

Maties (the name[1] of which is a corruption of the Dutch word for a maiden) resemble the fry in these particulars; but, if they are well fed, the deposit of fatty and other nutritive matter takes place, not only about the abdominal viscera, but also beneath the skin and in the interstices of the flesh. Indeed, when nourishment is abundant, this infiltration of the flesh with fat may go so far that the fish cannot readily be preserved and must be eaten fresh. The singularly delicate Loch Fyne herrings are in this condition early in the season. When the small crustaceans, on which the maties chiefly feed, are extremely abundant the fish gorge themselves with them to such an extent that the conical crop becomes completely distended, and the Scotch fishermen give them the name of "gut-pock herrings," as much as to say pouch-gutted fish, and an absurd notion is current that these herrings are diseased. However, the "gut-pock" herrings differ from the rest only in having their pouch full instead of empty, as it commonly is.

As the fish passes from the matie to the full condition, the milt and roe begin to grow at the expense of the nutriment thus stored up; and, as these organs become larger and occupy more and more space in the abdominal cavity, the excess of nutritious substance is transferred to them. The fatty deposit about the intestine and pyloric cæca gradually disappears and the flesh becomes poorer. It would appear that by degrees the fish cease to feed at all. At any rate, there is usually no food in the stomach of a herring which approaches maturity. In all these respects there is the closest resemblance between the history of the herring and that of other fishes such as the salmon—the parr correspnding to the herring fry or sile, the grilse and the "clean fish" of larger size to the maties.

At length spawning takes place, the accumulated nutrition, transformed into eggs or spermatic fluid, is expelled, and the fish is left in that lean and depauperated state which makes a "shotten herring" proverbial. In this condition it answers to the salmon "kelt," and the milt or roe are now shrunk and flaccid and can be blown up with air like empty bags. If the spent fish escapes its myriad enemies, it doubtless begins to feed again and once more passes into the matie state in preparation for the next breeding season. But the nature of this process of recuperation has yet to be investigated.

When they have reached the matie stage, the herrings, which are at all times gregarious, associate together in conspicuous assemblages, which are called shoals. These are sometimes of prodigious extent—indeed eight or nine miles in length, two or three in breadth, with an unknown depth, are dimensions which are credibly asserted to be sometimes attained. In these shoals the fish are closely packed, like a flock of sheep straying slowly along a pasture, and it is probably quite safe to assume that there is at least one fish for every cubic foot of water occupied by the shoal. If this be so, every square mile of such a shoal, supposing it to be three fathoms deep, must contain more than 500,000,000 herrings. And when it is considered that many shoals approach the coasts, not only of our own islands, but of Scandinavia and the Baltic, and of Eastern North America, every spring and autumn, the sum total of the herrings which people our seas surpasses imagination.

If you read any old and some new books on the natural history of the herring, you will find a wonderful story about the movements of these shoals. How they start from their home in the Polar Seas, and march south as a great armada which splits into minor divisions—one destined to spawn on the Scandi-

[1] "Halecum intestina, non modo multa gaudere obesitate, sed et totum corpus eo adeo esse impletum ut aliquando, cum discinditur, pinguedo ex cultro defluat, et præsertim eo quidem tempore ubi halecum lactes aut ova crescere primum incipiunt, unde nostrates eos *Maatgens-Haringen* dicere solent."—A. v. Leeuwenhoek, "Arcana Naturæ," Ep. xcvii. (1696).

Leeuwenhoek also mentions having heard of "gut pock" herrings from Scotch fishermen.

navian, and one on our own shores; and how, having achieved this spawning raid, the spent fish make their way as fast as they can back to their Arctic refuge, there to repair their exhausted frames in domestic security. This story was started in the last century, and was unfortunately adopted and disseminated by our countryman Pennant. But there is not the least proof that anything of the kind takes place, and the probabilities are wholly against it. It is, for example, quite irreconcilable with the fact that herring are found in cods' stomachs all the year round. And the circumstance to which I have already adverted, that practised eyes distinguish local breeds of herrings, though it does not actually negative the migration hypothesis, is very much against it. The supposition that the herring spawn in the north in the early spring, and in the south in the autumn, fitted very well into the notion that the vanguard of the migrating body of herrings occupied the first spawning ground it reached, and obliged the rest of the horde to pass on. But, as a matter of fact, the northern herrings, like the southern, have two spawning times; or perhaps it would be more correct to say that the spawning time extends from autumn to spring, and has two maxima—one in August-September, and one in February-March.

Finally, there is no evidence that herrings are to be met with in the extreme north of their range, at other times, or in greater abundance, than they are to be found elsewhere.

In the matter of its migration, as in other respects, the herring compares best with the salmon. The ordinary habitation of both fishes is no doubt the moderately deep portion of the sea. It is only as the breeding time draws near that the herrings (not yet advanced beyond the matie state) gather together towards the surface and approach the land in great shoals for the purpose of spawning in relatively or absolutely shallow water. In the case of the herring of the Schlei we have almost the connecting link between the exclusively marine ordinary herring and the river-ascending salmon.

The records of the herring fisheries are, for the most part, neither very ancient nor (with the exception of those of the Scotch Fishery Board) very accurately kept; and, from the nature of the case, they can only tell us whether the fish in any given year were readily taken or not, and that may have very little to do with the actual strength of the shoals.

However, there is historical evidence that, long before the time of Henry the First, Yarmouth was frequented by herring fishers. This means that, for eight centuries, herrings have been fished on the English coast, and I cannot make out, taking one year with another, in recent times, that there has been any serious fluctuation in their numbers. The number captured must have enormously increased in the last two centuries, and yet there is no sign of diminution of the shoals.

In 1864, we had to listen to dolorous prophecies of the coming exhaustion of the Scotch herring fisheries. The fact that the returns showed no falling off was ascribed to the improvement of the gear and methods of fishing, and to the much greater distances to which the fishermen extend their operations. Yet what has really happened? The returns of subsequent years prove, not only that the average cure of the decade 1869-78 was considerably greater than that of the previous decade, but that the years 1874 and 1880 are absolutely without parallel in the annals of the Scotch herring fishery, a million barrels having been cured in the first of these years, and a million and a half in 1880. In the decade 1859-68, the average was 670,000 barrels, and the highest 830,000.

In dealing with questions of biology, *à priori* reasoning is somewhat risky, and if any one tells me "it stands to reason" that such and such things must happen, I generally find reason to doubt the safety of his standing.

It is said that "it stands to reason" that destruction on such a prodigious scale as that effected by herring fishers must tell on the supply. But again let us look at the facts. It is said that 2,500,000,000, or thereabouts, of herrings are every year taken out of the North Sea and the Atlantic. Suppose we assume the number to be 3,000,000,000 so as to be quite safe. It is a large number undoubtedly, but what does it come to? Not more than that of the herrings which may be contained in one shoal, if it covers half a dozen square miles—and shoals of much larger size are on record. It is safe to say that, scattered through the North Sea and the Atlantic, at one and the same time, there must be scores of shoals, any one of which would go a long way towards supplying the whole of man's consumption of herrings. I do not believe that all the herring fleets taken together destroy 5 per cent. of the total number of herrings in the sea in any year, and I see no reason to swerve from the conviction my colleagues and I expressed in our Report, that their destructive operations are totally insignificant when compared with those which, as a simple calculation shows, must regularly and normally go on.

Suppose that every mature female herring lays 10,000 eggs, that the fish are not interfered with by man, and that their numbers remain approximately the same year after year, it follows that 9998 of the progeny of every female must be destroyed before they reach maturity. For if more than two out of the 10,000 escape destruction, the number of herrings will be proportionately increased. Or in other words, if the average strength of the shoals which visit a given locality is to remain the same year by year, many thousand times the number contained in those shoals must be annually destroyed. And how this enormous amount of destruction is effected will be obvious to any one who considers the operations of the fin-whales, the porpoises, the gannets, the gulls, the codfish, and the dogfish, which accompany the shoals and perennially feast upon them; to say nothing of the flat-fish, which prey upon the newly-deposited spawn; or of the mackerel, and the innumerable smaller enemies which devour the fry in all stages of their development. It is no uncommon thing to find five or six—nay, even ten or twelve—herrings in the stomach of a codfish,[1] and, in 1863, we calculated that the whole take of the great Scotch herring fisheries is less than the number of herrings which would in all probability have been consumed by the codfish captured in the same waters if they had been left in the sea.[2]

Man, in fact, is but one of a vast co-operative society of herring-catchers, and the larger the share he takes, the less there is for the rest of the company. If man took none, the other shareholders would have a larger dividend, and would thrive and multiply in proportion, but it would come to pretty much the same thing to the herrings.

As long as the records of history give us information, herrings appear to have abounded on the east coast of the British Islands, and there is nothing to show, so far as I am aware, that, taking an average of years, they were ever either more or less numerous than they are at present. But in remarkable contrast with this constancy, the shoals of herrings have elsewhere exhibited a change capriciousness—visiting a given locality for many years in great numbers, and then suddenly disappearing. Several well-marked examples of this fickleness are recorded on the west coast of Scotland; but the most remarkable is that furnished by the fisheries of Bohüslan, a province which lies on the south-western shore of the Scandinavian peninsula. Here a variety known as the "old" or

[1] In his valuable Report on the Salt Water Fisheries of Norway (1877), Prof. Sars expresses the belief that full-grown codfishes feed chiefly, if not exclusively, on herrings.

[2] In 1879 rather more than 5,000,000 cod, ling, and hake, were taken by the Scottish fishermen. Allowing each only two herrings a day, these fishes would have consumed more than three thousand five hundred million of herrings in a year. As to the Norwegian fisheries, 20,000,000 codfishes are said to be taken annually by the Lofoden fishermen alone.

"great" herring, after being so extremely abundant, for about sixty years, as to give rise to a great industry, disappeared in the year 1808, as suddenly as they made their appearance, and have not since been seen in any number.

The desertion of their ordinary grounds by the herring has been attributed to all imaginable causes, from fishing on a Sunday to the offence caused to the fish by the decomposing carcases of their brethren, dropped upon the bottom out of the nets. The truth is that absolutely nothing is known on the subject; and that little is likely to be known, until careful and long-continued meteorological and zoological observations have furnished definite information respecting the changes which take place in the temperature of the sea, and the distribution of the pelagic crustacea which constitute the chief food of the herring shoals. The institution of systematic observations of this kind is an object of international importance, towards the attainment of which the British, Scandinavian, Dutch, and French Governments might wisely make a combined effort.

A great fuss has been made about trawlers working over the spawning grounds of the herring. "It stands to reason," we were told, that they must destroy an immense quantity of the spawn. Indeed this looked so reasonable, that we inquired very particularly into a case of the alleged malpractice which was complained of on the east coast of Scotland, near Pittenweem. Off this place, there is a famous spawning ground known as the Traith hole, and we were told that the trawlers worked vigorously over the spot immediately after the herring had deposited their spawn. Of course our first proceeding was to ask the trawlers why they took the trouble of doing what looked like wanton mischief. And their answer was reasonable enough. It was to catch the prodigious abundance of flat-fish which were to be found on the Traith at that time. Well, then, why did the flat-fish congregate there? Simply to feed on herring eggs, which seem to be a sort of flat-fishes' caviare. The stomachs of the flat-fish brought up by the trawl were, in fact, crammed with masses of herring eggs.

Thus every flat-fish caught by the trawl was an energetic destroyer of herring arrested in his career. And the trawling, instead of injuring the herring, captured and removed hosts of their worst enemies. That is how "it stood to reason" when one got to the bottom of the matter.

I do not think that any one who looks carefully into the subject will arrive at any other conclusion than that reached by my colleagues and myself: namely, that the best thing for Governments to do in relation to the herring fisheries, is to let them alone, except in so far as the police of the sea is concerned. With this proviso, let people fish how they like, as they like, and when they like. At present, I must repeat the conviction we expressed so many years ago, that there is not a particle of evidence that anything man does has an appreciable influence on the stock of herrings. It will be time to meddle, when any satisfactory evidence that mischief is being done is produced.

NOTES

THE fifty-first Annual Meeting of the British Association for the Advancement of Science will commence at York on Wednesday, August 31, 1881. The President-Elect is Sir John Lubbock, Bart, M.P., F.R.S. Vice-Presidents Elect: His Grace the Archbishop of York, D.D., F.R.S.; the Right Hon. the Lord Mayor of York; the Right Hon. Lord Houghton, F.R.S.; the Ven. Archdeacon Creyke, M.A.; the Hon. Sir W. R. Grove, F.R.S.; Prof. G. G. Stokes, Sec. R.S.; Sir John Hawkshaw, C.E., F.R.S.; Allen Thomson, M.D., F.R.S. L. and E.; Prof. Allman, M.D., F.R.S. L. and E. General Secretaries: Capt. Douglas Galton, C.B., D.C.L., F.R.S.; Philip Lutley Sclater, Ph.D., F.R.S. Acting Secretary: George Griffith, M.A., F.C.S., Harrow; General Treasurer: Prof. A. W. Williamson, F.R.S., University College, London, W.C. Local Secretaries: Rev. Thomas Adams, M.A.; Tempest Anderson, M.D., B.Sc., York. Local Treasurer: W. W. Wilberforce, York. The Sections are the following:—A.—Mathematical and Physical Science.—President: Prof. Sir William Thomson, F.R.S. L. and E. Vice-Presidents.—Prof. J. C. Adams, F.R.S.; T. Archer Hirst, Ph.D., V.P.R.S. Secretaries: Prof. W. E. Ayrton; Oliver J. Lodge, D.Sc.; Donald McAlister, B.A., B.Sc. (Recorder). B.—Chemical Science.—President: Prof. A. W. Williamson, For. Sec. R.S., V.P.C.S. Vice-Presidents: F. A. Abel, C.B., F.R.S.; Prof. Odling, F.R.S. Secretaries: Harold B. Dixon, M.A.; P. Phillips-Bedson, D.Sc. (Recorder). C.—Geology.—President: Andrew Crombie Ramsay, LL.D., F.R.S., Director-General of the Geological Survey of the United Kingdom and of the Museum of Practical Geology. Vice-Presidents: Prof. Prestwich, F.R.S.; Prof. W. C. Williamson, F.R.S.; Secretaries: W. Topley, F.G.S. (Recorder); W. Whitaker, F.G.S. D.—Biology.—President: Richard Owen, C.B., F.R.S. Vice-Presidents: Prof. W. H. Flower, F.R.S.; Prof. J. S. Burdon Sanderson, F.R.S. Secretaries: G. W. Bloxam, M.A., F.L.S.; W. L. Distant; W. A. Forbes, F.Z.S.; Prof. M'Nab, M.D.; John Priestley; Howard Saunders, F.L.S., F.Z.S. Department of Zoology and Botany.—Richard Owen, C.B., F.R.S. (President), will preside. Secretaries: Prof. M'Nab, M.D. (Recorder); Howard Saunders, F.L.S., F.Z.S. Department of Anthropology.—Prof. W. H. Flower, F.R.S. (Vice-President), will preside. Secretaries: G. W. Bloxam, M.A., F.L.S. (Recorder); W. L. Distant. Department of Anatomy and Physiology.—Prof. J. S. Burdon Sanderson, F.R.S. (Vice-President), will preside. Secretaries: John Priestley (Recorder); W. A. Forbes, F.Z.S. E.—Geography.—President: Sir J. D. Hooker, K.C.S.I., C.B., F.R.S. Vice-Presidents: Francis Galton, F.R.S.; Prof. Sir C. Wyville Thomson, F.R.S. L. & E. Secretaries: H. W. Bates, Assist.-Sec.R.G.S., F.L.S.; E. C. Rye, Librarian R.G.S., F.Z.S. (Recorder). F.—Economic Science and Statistics.—President: The Right Hon. M. E. Grant Duff, M.P., F.R.S. Vice-Presidents: Sir George Campbell, K.C.S.I., M.P.; James Heywood, F.R.S. Secretaries: Constantine Molloy (Recorder); J. F. Moss. G.—Mechanical Science.—President: Sir W. G. Armstrong, C.B., F.R.S. Vice Presidents: W. H. Barlow, F.R.S., Pres.Inst.C.E.; C. W. Siemens, D.C.L., F.R.S. Secretaries: A. T. Atchison, M.A. (Recorder); H. Trueman Wood, B.A. Tickets for the meeting may be obtained of the Local Secretaries at York, and at the Office of the Association, 22, Albemarle Street, London, W.; or on application by letter, from August 17 to August 24, to the General Treasurer, Prof. A. W. Williamson, British Association, University College, London, W.C. The First General Meeting will be held on Wednesday, August 31, at 8 p.m. precisely, when A. C. Ramsay, F.R.S., V.P.G.S., Director-General of the Geological Survey of the United Kingdom, and of the Museum of Practical Geology, will resign the chair, and Sir John Lubbock, Bart., M.P., F.R.S., President-Elect, will assume the presidency, and deliver an address. On Thursday evening, September 1, at 8 p.m., a *soirée;* on Friday evening, September 2, at 8.30 p.m., a discourse by T. H. Huxley, LL.D., Sec.R.S., Professor of Natural History in the Royal School of Mines; on Monday evening, September 5, at 8.30 p.m., a discourse by W. Spottiswoode, D.C.L., LL.D., President of the Royal Society; on Tuesday evening, September 6, at 8 p.m., a *soirée;* on Wednesday, September 7, the concluding general meeting will be held at 2.30 p.m. No report, paper, or abstract, can be inserted in the Report of the Association unless it is given in before the conclusion of the meeting. Excursions to places of interest in the neighbourhood of York will be made on the afternoon of Saturday, September 3, and on Thursday, September 8.

THE honorary degree of LL.D. has been conferred on the following gentlemen by the University of Glasgow:—F. M. Balfour, M.A., Fellow of Trinity College, Cambridge; Dr. Angus Smith, F.R.S., Government Inspector of Alkali Works; Prof. Richard Owen, C.B., F.R.S., Superintendent of Natural History Collections of the British Museum; Andrew Buchanan, M.D., Emeritus Professor of Physiology in the University of Glasgow.

THE honorary degree of LL.D. has been conferred by the University of Edinburgh on Prof. A. W. Williamson, of University College, London.

IT is intended to celebrate in Edinburgh the centenary of the birthday of Sir David Brewster, on December 9, by a public dinner.

THE annual meeting of the Iron and Steel Institute will be held in London on May 4, 5, and 6. On May 4 the Bessemer Medal for 1881 will be presented to Mr. William Menelaus, and the president-elect (Mr. Josiah T. Smith) will deliver his inaugural address. The following is the list of papers to be read:—On the Results of Experiments relative to Corrosion in Iron and Steel, by Mr. William Parker of Lloyd's Registry, London; On the Manufacture of Armour Plates, by Mr. Alexander Wilson, Sheffield; On the Manufacture of Steel and Steel Plates in Russia, by Mr. Sergius Kern, St. Petersburg; On the Use of Steel for Shipbuilding, by Mr. William Denny, Dumbarton; On some Physical Properties of Cast Iron, by Mr. Charles Markham, Staveley; On the Desulphurisation of Iron, by M. Rollet, St. Chamond, France; On Iron and Steel Permanent Way, by Mr. R. Price Williams, London; On Hydraulic Appliances for the Bessemer Process, by Mr. Michael Scott, London; On the Manufacture of Bessemer Steel and Steel Rails in America, by Capt. Jones, Edgar Thomson Steel Works, Pittsburg, U.S.A.; On Hydrogen and Carbonic Oxide in Iron and Steel, by Mr. John Parry, Ebbw Vale; On the Preservation of Iron and Steel Surfaces, by Mr. George Bower, St. Neots; On a new method for the determination of Oxygen in Iron and Steel, by Mr. Alex. E. Tucker, Rhymney.

DURING the Summer Term of the City and Guilds of London Institute, commencing May 2, 1881, Prof. Armstrong, Ph.D., F.R.S., and Prof. Ayrton, A.M., Inst.C.E., will continue their tutorial and laboratory courses of instruction in chemistry and physics as applied to the arts and manufactures, at the Cowper Street Schools, pending the present erection of the City and Guilds of London Technical College, Finsbury, the foundation stone of which will be laid by Prince Leopold on May 10. There are both day and evening classes at the institute, with means for ample laboratory practice, at fees which place the education within reach of all classes. We would specially draw attention to the fact that these classes and the laboratory practice are open, at an almost nominal fee, to female as well as to male students. For every hour of lecture there are two hours laboratory work included in this nominal fee. The day classes would be of service to girls who have not the means to obtain a Girton or a Newnham education, while the evening classes will be of great use to those women who take more than a mechanical interest in their daily work; for from the course of instruction and their own work in the laboratory they will gain such a thorough knowledge of principles as should distinguish a skilled workwoman from a mere machine.

THE Annual Report for the past year of the Jamaica Public Gardens, by Mr. D. Morris, the new director, is one of great interest. As the year has been the first under the new organisation, the chief work has naturally been of a departmental character, but from the details given, it is evident that important advances have been made in developing several industries which must have an important influence for good on the future of the island. From the variation in altitude of the different gardens under Mr. Morris's charge excellent opportunities are afforded for experimenting on various kinds of cultivation, and these he is evidently prepared to take full advantage of. Among the various cultures, concerning which interesting information is contained in the Report, are Cinchona, Liberian Coffee, Sugar Canes, Teak and Mahogany, Pine-Apples, Jalap, Cacao, Tobacco, India-Rubber, various spices, Oranges, Banana Fibre, &c. The best results may be looked for from Mr. Morris's vigorous and intelligent directorship.

WE have also a very satisfactory Report of work for the year ending March 31, 1880, from Mr. Duthie, superintendent of the Government Botanical Gardens at Saharanpor and Mussooree. As in Jamaica, experiments, some of them very successful, have been carried on in the rearing of various useful plants, including vegetable and medicinal plants. Much difficulty has been experienced by Mr. Duthie in training *Mallies* for work in the gardens, and he has some trials before him ere he is able to turn out a staff of properly-trained natives.

MR. M. G. MULHALL sends us the following curious note, which we give without comment:—"Although Shakespeare is supposed to have taken the idea of Hamlet from the Danish historian Saxo-Grammaticus, there are such points of resemblance with the Arabic chronicle of Nigiaristan, respecting Montasser, tenth Caliph of Bagdad, that I venture to call your attention to the same. The points of analogy are as follows: 1. That Montasser is murdered by putting poison in his ear. 2. The ghost scene, in which his father appears to him. 3. The displaying of tapestry before the Caliph and his court, in which the tapestry represents a tragedy identical with the late Caliph's murder."

THE *Daily News* New York correspondent telegraphs that the aldermen have passed, over the mayor's veto, the ordinance giving the Edison Electric Lighting Company permission to lay tubes in the streets. "The company will proceed immediately to introduce its new electric lamps in the offices in the business portion of the city around Wall Street. The construction of the lamp is simple. It consists of a small bulbous glass globe, four inches long, an inch and a half in diameter, with a carbon loop which becomes incandescent when the electric current passes through. Each lamp is of sixteen candle-power, with no perceptible variation in intensity. The light is turned on or off with a thumbscrew. Wires have already been put into forty buildings. The company will compete with the gas companies by charging the same rates. If the latter reduce, the Edison Company will also reduce, and are prepared to go lower than the gas companies can."

AT five o'clock on Saturday morning a strong shock of earthquake was felt at Paola in the province of Calabria. On the night of April 19 there was another severe shock of earthquake at Chios.

A NEW illustrated work on the Butterflies of Europe is, we understand, in active preparation by Dr. Lang, F.L.S. Its publication, in monthly parts, will be commenced very shortly by Messrs. Lovell, Reeve, and Co.

MRS. BURTON, the wife of the well-known Capt. R. Burton, our Consul at Trieste, is evidently doing a good work in that city in teaching the people kindness to animals. The lesson is evidently much needed, and judging from Mrs. Burton's speech at her last fête and distribution of prizes, her efforts are meeting with decided success. Of course all this costs money; possibly some of our readers may be inclined to help by sending a contribution to Mrs. Richard Burton, British Consulate, Trieste, Austria.

OWING to the outcry caused by the sale to a private person of the Katoomba Falls, in the Blue Mountains, the New South Wales Government, according to the *Colonies and India*, has set apart for public use large tracts of land round Dangar's Falls, near Armidale, the Great Falls in the same district, and Moona Falls, near Walcha, in imitation of the reserves or national parks in the United States of America.

A REMARKABLE frost is said to have occurred in Guatemala on February 10, doing great damage to the tropical vegetation.

IN the review of Messrs. Fison and Howitt's "Kamilaroi and Kurnai" that appeared last week, we should have mentioned that the book is published in England by Messrs. Macmillan and Co.

FROM Glasgow we have received two satisfactory Reports—that of the Industrial Museum, presided over by Mr. James Paton, and that of the Mitchell Library, under Mr. F. T. Barrett.

TWO HUNDRED AND TEN school teachers nominated on purpose by the 30,000 public teachers of elementary schools in France, and travelling at the expense of the Government, were summoned to Paris in order to hold a Pedagogic Congress, which came to a close on the 24th. At the same time the Ligue de l'Enseignement, founded by M. Jean Macé, held a series of meetings at the Trocadéro. The concluding sitting, which took place last Thursday, was attended by all the school teachers and an immense number of political leaders. M. Gambetta delivered a speech praising the advantages of education, commending school teachers as a body, and advocating the importance of interesting ladies in the general diffusion of knowledge.

MESSRS. MARSHALL JAPP, AND CO., have published a useful little Half-Holiday Handbook of Geological Rambles around London, which will be found to add much interest to a Saturday afternoon walk into the country.

MR. H. L. JANSSEN VAN RAAY writes to us from Batavia, March 21, that in the enumeration of the different geographical societies of the world in NATURE, vol. xxiii. p. 299, the Geographical Society at Samarang (Java), founded in 1879, was omitted.

FIDELIS BUTSCH SOHN of Augsburg has issued a priced catalogue of the extensive library of the late Prof. W. P. Schimper of Strassburg.

THE new number of the *Proceedings* of the Bristol Natural History Society contains some good papers:—Some Optical Illusions, by Prof. S. P. Thompson; Underground Temperature, by Mr. E. Wethered; The Structure and Life-History of a Sponge, by Mr. W. G. Sollas; On some Cases of Prolification in *Cyclamen Persicum*, by Mr. A. Leipner; The Ethnology of the Paropamisus, by Dr. J. Beddoe, F.R.S.; Catalogue of the Lepidoptera of the Bristol District, by Mr. A. E. Hudd, and of the Fungi, by Mr. C. Bucknall; The Pomarine Skua, by M. H. Charbonnier.

THE additions to the Zoological Society's Gardens during the past week include three Short-tailed Wallabys (*Halmaturus brachyurus*) from West Australia, presented by Sir Harry St. George Ord, C.B., H.M.Z.S.; three Green Lizards (*Lacerta viridis*) from Jersey, presented by Mr. E. H. Bland; a Rufous Rat Kangaroo (*Hypsiprymnus rufescens*) from Australia, presented by Mr. A. W. Wyatt; a Lion (*Felis leo* ♀) from Africa, deposited; three Entellus Monkeys (*Semnopithecus entellus* ♂ ♂ ♀) from India, purchased; a Lion (*Felis leo* ♀) from Africa, a Common Otter (*Lutra vulgaris* ♀), British, received in exchange; a Collared Fruit Bat (*Cynonycteris collaris*), a Vulpine Phalanger (*Phalangista vulpina*), born in the Gardens.

CHEMICAL NOTES

IN *Journal pract. Chemie*, Herr Cech, in the course of a paper on the decompositions which occur during the rotting of eggs, describes experiments which he thinks establish the possibility of obtaining a good soap free from smell, by saponifying with soda the residue obtained by evaporating to dryness rotten eggs, freed from their shells. Such a dried residue yields about 10·5 per cent. of oil, fresh eggs giving about 11 per cent.

THE changes undergone by grain when stored in underground magazines have been recently studied by M. Müntz (*Compt. rend.*). The magazines of the Paris Omnibus Company are partly underground; the grain in the upper parts is, however, exposed to the influence of atmospheric changes; it is found to contain much more moisture and to be at a higher temperature than that in the lower parts. The relative amounts of deterioration in grains may be measured by the quantities of carbonic anhydride exhaled. When grain is freely exposed to air about ten times as much carbonic anhydride is given off as when the grain is kept in closed receptacles; less oxygen is absorbed than corresponds with this evolution of carbon dioxide. Normal grain contains from 11 to 19 per cent. of moisture: the greater the moisture the greater the exhalation of carbon dioxide. The amount of the gas evolved also increases with increase of temperature until a point is reached at which true chemical combustion of the carbon begins, as distinguished from the physiological combustion which has preceded it. Grain which is to be kept for any time ought to be very dry, the receptacle containing it ought to be completely closed, and all parts of this receptacle ought to be at approximately the same temperature.

MR. V. LEWES, in the same journal, describes barium pentathionate, $BaS_5O_6 . 3H_2O$, and several potassium pentathionates, prepared by slow evaporation in a vacuum of "Wackenroder's solution." These experiments appear to establish beyond doubt the existence of pentathionic acid.

DRS. DUPRÉ AND HAKE have applied their method for the estimation of carbon (*Chem. Soc. Journ.*)—viz. burning in oxygen, absorbing carbonic anhydride in baryta water, converting the barium carbonate into sulphate, and weighing as such—to the estimation of carbon in air; their experiments apparently demonstrate the presence in London air of carbon in forms other than carbonic anhydride, and probably in the form of some volatile organic compounds, not as suspended matter. Drs. Dupré and Hake claim that their method of analysis enables them to estimate carbonic anhydride, carbon in the peculiar forms already noticed, and suspended carbonaceous matter in air.

IN the same journal there is a contribution to the history of ozone by Prof. Hartley of Dublin. The main conclusions drawn from experimental data are these: Ozone is a normal constituent of the higher atmosphere, and is present therein in larger proportion than near the surface of the earth. The limitation of the solar spectrum in the ultra-violet is readily accounted for by the absorptive action of atmospheric ozone, without taking into account the possible absorptive power of nitrogen and oxygen. The blue tint of the atmosphere is probably due to ozone. It is shown in the paper that the wave-length of the extreme ray capable of absorption by considerable quantities of ozone is about 316. A quantity of 2·5 mgm. of ozone in each square centimetre of sectional area of a column of air produces, it is said, a full sky-blue tint. Incidentally experiments are described in which one volume of ozone was distinctly detected by the sense of smell in 2,500,000 volumes of air.

MR. G. S. JOHNSON has obtained ammonia (*Chem. Soc. Journal*) by passing hydrogen and (presumably) pure nitrogen over cold or moderately heated spongy platinum: when however the mixed gases were passed over hot asbestos before traversing the spongy platinum, *no* ammonia was formed. Mr. Johnson thinks that nitrogen probably exists in two forms, an active and an inactive form, the latter being produced by the action of heat on the former.

DR. DUPRÉ has introduced (*Analyst*) a slight modification into the ordinary method for observing a colour change in titrating with standard solutions, which is said to render the perception of the change very sharp and accurate. He views the liquid to be titrated through a glass cell containing a solution of the same colour as, and about equal in intensity to, the liquid itself.

M. LONGUININE has recently determined (in *Compt. rend.*) the heats of combustion of various alcohols of the allyl series, and compared the numbers with those expressing the heats of combustion of metameric aldehydes. He finds very marked differences between the two series of numbers, showing once more a distinct connection between the energy lost by a carbon compound in passing from one state to another standard state, and the structure of the molecule of that compound.

M. BERTHELOT, in continuation of his researches on compounds of metallic halogen salts with haloid acids, describes in *Compt. rend.* the action of gaseous hydrochloric and hydrobromic acids on alkali chlorides and bromides; he shows that the gaseous acids are absorbed by the dry salts with disengagement of heat, and that the products of the actions are possessed of properties which distinguish them from mere mixtures.

M. BERTHELOT also considers the reciprocal actions between alkali haloid salts and haloid acids; he shows that as a rule alkali chlorides are decomposed by hydrobromic acid, but that in some cases and under special conditions of temperature, bromides are decomposed by hydrochloric acid. The general results are shown to be in keeping with the laws of thermochemistry. That action in which most heat is evolved occurs, but the products of the action may be unstable under experimental conditions, and hence the primary change may be modified, or even reversed.

M. MÜNTZ states that his investigations have shown that traces of alcohol exist in all natural waters, whether rain, river, sea, or snow water. He describes his method of applying the iodoform test for alcohol, whereby one part can be detected in 1,000,000 parts of water.

PHYSICAL NOTES

M. LAURENT of Paris has constructed "magic mirrors" giving similar effects to those brought from Japan, but of glass silvered at the back instead of metal. By engraving patterns at the back and silvering the front surface, the mirror has a perfectly plane surface only when the air-pressures at the front and back are equal. If the air behind be compressed or rarefied the thinner parts will have relatively a greater convexity or concavity than the rest, and in the disk of light which the mirror reflects on to a wall from a luminous point the pattern engraved on the back will accordingly appear dark or light.

FROM experiments on the radiation and conduction of heat in rarefied gases (*Wied. Ann.*, No. 13) Herr Graetz finds the results in much better agreement with Stefan's law of radiation than with that of Dulong and Petit, and "it may be affirmed that in the temperature-interval from 0° to 250° C. the radiation is very nearly proportional to the fourth power of the temperature." The factor of proportionality σ (in Stefan's formula $Q = \sigma T^4$) is then that amount of heat which is radiated from one square centimetre of a substance of $-272°$ C. in a second towards a space of the absolute temperature 0° ($-273°$). By the method of least squares Herr Graetz finds

$$\sigma \text{ for glass} = 1\cdot 0846^{-12} \frac{\text{gramme centigrade}}{\text{centim. seconds}}.$$

Certain divergences at low temperatures suggest that while the intensity of radiation grows with rising temperature, it perhaps grows differently for different heat colours.

IN a recent communication to the Munich Academy, Herren Nies and Winkelmann describe an inquiry into the volume-changes of various metals in solidifying. Of eight metals examined, six (viz. tin, zinc, bismuth, antimony, iron, and copper) were proved to undergo expansion in passing from the liquid to the solid state. For three of the metals approximate values for the amount of this expansion were obtained (tin showed an expansion of 0·7 per cent., zinc 0·2, and bismuth 3). Two metals (lead and cadmium) gave doubtful results; but the authors find some reason to believe that they also expand in solidifying. So far then the rule would appear to be general for metals.

M. TRÈVE describes in the *Comptes rendus* some curious observations from which it would appear that when light is admitted from a natural or artificial source through a slit, more light passes if the slit be horizontal than if it be vertical. M. Trève has produced photographs taken behind slits in various positions to prove that the effect is not an illusion of the eye. The phenomenon appears to us inexplicable, but certainly requires further proof to substantiate its reality.

M. MERCADIER still continues to study radiophonic phenomena. He finds it possible to increase the effects by uniting in one tube the vibrations of several receiving disks. He also finds it possible to construct tubes whose length corresponds to the wave-length of the vibrations radiophonically excited, and which respond to the note emitted. M. Mercadier hopes by these means to re-determine with increased accuracy the velocity of sound in air and other gases.

WITH regard to the beats and beat-tones of harmonic intervals Dr. Koenig argues (*Wied. Ann.* No. 3) against Prof. Helmholtz's view, that these are due to harmonic tones of the lower primary sounding with the higher (Dr. Koenig, in his former experiments, having used strongly-excited tuning-forks). He shows how the phenomena may be studied with the aid of a "wave-syren," in which a blast of air is sent through a slit against the serrated border of a rotating disk, or of a ring-section of a thin cylinder. He has the border of the disk cut to represent accurately the curve produced by combination of the curves of two simple tones, giving an air-motion, when blown against, quite like that from the two tones sounded together. The beats and beat-tones are then heard. With a mere wavy outline for the border and the slit at right angles one hears a quite simple tone, which however is at once changed to a "clang" with strong overtones, when the slit is slanted a little. Now, with two simple tones got thus the beat-tone heard when the slits are at right angles should (on Helmholtz's supposition) be less distinct than when, the slits being slanted, the overtones are brought out; whereas the reverse is the case.

DR. KOENIG, in the same number, describes a simple lecture-apparatus for producing beat-tones. It consists of two glass rods of different length, clamped in vertical position by the middle to a jointed frame, which, through an elastic contrivance, keeps their lower ends pressed against the cloth-covered periphery of a wheel which dips in water in a trough. The friction calls forth the longitudinal tones and the beat-tone.

AN improved form of the Töpler air-pump has been devised by Herr Bessel-Hagen (*Wied. Ann.* No. 3), with which considerably higher vacua can be reached than those Mr. Crookes obtains with the more complicated and fragile Sprengel-Gimingham apparatus. The average limit of rarefaction was found to be $\frac{1}{63}$ millionths of an atmosphere ($\frac{1}{96}$ in one case), while the other pump only gives $\frac{1}{17}$ millionth. (It is noted that Prof. Ogden Rood has obtained $\frac{1}{94}$, and in one case even $\frac{1}{110}$ with a modified Sprengel.) With his highest vacua the author found electricity to pass (using plate-electrodes and a strong Holtz machine, with Leyden jars). He considers mercury-vapour an insulator for electricity; but shows that radiometric movements depend greatly on its pressure *in vacuo*. No diffusion of hydrogen through the glass could be detected.

AN artificially-formed body showing polar effects in the way of attraction and direction is produced by Herr Holtz (*Wied. Ann.*, No. 3) thus: To one end of a short glass rod is cemented a plane piece of glass, and to this a short narrow glass tube (in a line with the rod). In the tube is placed a sewing-needle longer than it, and carrying at its head a thin pasteboard disk (22 mm. across), which has attached on one half of its periphery, reaching over both above and below, a pasteboard strip (10 mm. broad); opposite this, on one of the surfaces, is fastened a small projecting point of tin-foil. Brought between hollow disks fixed to the rods of a Holtz machine, the tin-foil point always turned to the positive pole. Next, the glass rod with its disk was attached to the end of a light horizontal glass tube, hung bifilarly, and so brought between the hollow disks. The disk first turned into position, and was then attracted towards the negative pole. The phenomena are thought to illustrate unipolar conductivity.

THE simple tourmaline-pincette, by reason of its small field, can be used with only a small number of crystals. To enlarge the field M. Bertin has applied to it a part of the lenses of the polarising microscope. This, it is known, consists, first, of a polariser and focus; second, of a microscope and analyser. The polariser and analyser, at the extremities, are pretty large pieces, and if replaced by two tourmalines placed between the focus and the microscope (of simplified form) the apparatus is rendered much smaller and handier. This is the principle of M. Bertin's new tourmaline-pincette (of which details will be found in the

Journal de Physique for March). It shows very well the fringes of a crystal only 2 mm. in diameter and $\frac{1}{2}$ mm. in thickness, and all uniaxial crystals give fringes in it. With the old pincette only two biaxial crystals can be observed (nitre and lead crystal), the limit for the exterior angle of the axis being about 17°; but in the new instrument, a small calamine plate, with axes 78° 20′ apart, showed the fringes well.

ACCORDING to M. Angot (*Jour. de Phys.*, March) the psychrometer, of whatever form, may give pretty good indications in the hands of careful observers, in these regions (France), so long as the atmospheric pressure is not far from 760 mm., the wet bulb thermometer is above 1° or 2°, and the difference of the two thermometers remains below 12°; but otherwise the ordinary formulæ become illusory.

THE influence of atmospheric electricity on the vegetation of the vine has been studied near Palermo by M. Macagno (*Jour. de Agr. Prat.*) thus: Sixteen stocks were rendered more subject to the effects of the electric tension by means of a copper wire inserted vertically with platinum point in the upper end of the fruit branch, while another wire connected the bottom of the branch with the ground. This continued from April to September. An acceleration of vegetation was proved by the wood of these stocks containing less mineral matters and potash than that of the other stocks, while the contrary occurred in the leaves, and in these the potash was mostly in the bitartrate form. A much greater quantity of must was got from the grapes of those vines, and it had considerably more glucose and less acid.

A DETERMINATION of the electric phenomena which occur on contact of metals and gases has been attempted by Herr Schulze-Berge in Berlin (*Wied. Ann.* No. 2). He worked with a condenser having two circular plates of a given metal, the upper plate being connected with an electrometer and submitted to contact with various gases or to vacuum; the lower connected to earth. The quantity of electricity from a known source requiring to be communicated to the upper plate to make its potential equal to the lower, was measured. *Inter alia*, ozone was found to make gold, platinum, and brass negative to a plate of the same metal in air. Hydrogen always made platinum strongly positive, while its influence on gold was hardly perceptible, and on brass qualitatively various. Chlorine made platinum negative; ammoniacal gas (from aqueous solution) made brass positive. The amount of difference of potential with as similar treatment as possible of a given pair of plates was very different in the several observations of a series. Nor could a certain relation be discovered between it and the time of action of the gas. It was greatest with two platinum plates, one in hydrogen (viz. 0·214 D). It gradually decreased to a point generally somewhat short of that at the beginning. As to the cause of this decrease, the author thinks it probable that a gradual neutralisation of the electrical double layer takes place.

THE DEVELOPMENT OF HUMAN INTELLIGENCE

THE Department of Education of the American Social Science Association has issued the following Circular and Register, which we commend to the notice of our readers, some of whom may be able to give Mrs. Talbot answers to the questions given below:—

WE have been made familiar with the habits of plants and animals from the careful investigations which have from time to time been published—the intelligence of animals, even, coming in for a due share of attention. One author alone contributes a book of one thousand pages upon "Mind in the Lower Animals." Recently some educators in this country have been quietly thinking that to study the natural development of a single child is worth more than a Noah's ark full of animals. Little has been done in this study, at least little has been recorded. It is certain that a great many mothers might contribute observations of their own child's life and development that might be at some future time invaluable to the psychologist. In this belief the Education Department of the American Social Science Association has issued the accompanying Register, and asks the parents of very young children to interest themselves in the subject—

1. By recognising the importance of the study of the youngest infants.
2. By observing the simplest manifestations of their life and movements.
3. By answering fully and carefully the questions asked in the Register.
4. By a careful record of the signs of development during the coming year, each observation to be verified, if possible, by other members of the family.
5. By interesting their friends in the subject and forwarding the results to the secretary.
6. Above all, by *perseverance* and exactness in recording these observations.

From the records of many thousand observers in the next few years it is believed that important facts will be gathered of great value to the educator and to the psychologist.

First Series—REGISTER OF PHYSICAL AND MENTAL

Development of (Give the Baby's full name.) ....
Name and occupation of the father? ....
Place and time of father's birth? ....
,, ,, mother's ,, ? ....
,, ,, baby's ,, ? ....
Baby's weight at birth .... at 3 months? ....
,, ,, 6 months? ....at 1 year? ....
Is baby strong and healthy, or otherwise? ....
At what age did the baby exhibit consciousness, and in what manner? ....

AT WHAT AGE DID THE BABY

smile? ....
recognise its mother? ....
notice its hand? ....
follow a light with its eyes? ....
hold up its head? ....
sit alone on the floor? ....
creep? ....
stand by a chair? ....
stand alone? ....
walk alone? ....
hold a plaything when put in its hand? ....
reach out and take a plaything? ....
appear to be right or left handed? ....
notice pain, as the prick of a pin? ....
show a like or dislike in taste? ....
appear sensible to sound? ....
notice the light of a window or turn towards it? ....
fear the heat from stove or grate? ....
speak, and what did it say? ....

HOW MANY WORDS COULD IT SAY

at 1 year? .... at 18 months? .... at 2 years? ....

Will the mother have the kindness to carefully answer as many as possible of these questions and return this circular, before July 15, 1881, to Mrs. Emily Talbot, Secretary of the Education Department of the American Social Science Association, 66, Marlborough Street, Boston, Mass.

Boston, March 1, 1881

In connection with the inquiry indicated above, the following letter from Dr. Preyer of Prussia, addressed to Mrs. Talbot, will be found of interest:—

Jena, November 22, 1880

DEAR MADAM,—It has given me much pleasure to read your letter and the extract of a paper of mine on "psychogenesis," or "the growth of volition, intellect, &c., in infants," and I readily comply with your wish to have this paper sent off without delay. You will find it reprinted in the book accompanying this letter, p. 199–237. I am about to publish an extensive work on the same subject, which is to contain all my observations and a careful analysis of the phenomena which the development of the faculty of speech presents. This book is to be printed next year. I am sorry to say that a reliable investigator of the whole subject is not known to me. Your newspaper seems to be right in calling the field "as yet almost unbroken." Prof. Kussmaul's "Seelenleben des neugeborenen Menschen" (Leipzig and Heidleberg, 1859), and Mr. C. Darwin's biographical sketch of an infant, contain some good observations, but both are very short. Many excellent remarks on infants and very young children I find in Mr. C. Darwin's book, "On the Expression of the Emotions." The German books on the subject, although numerous, are nearly worthless; many are sentimental, giving no facts, or, what is worse, false statements. B. Sigismund's "Kind und Welt" (1851) is an exception.

The case you mention of a child of eleven months expressing its wishes and inducing the nurse to comply with them cannot be definitely looked at as a case of self-consciousness, but only of consciousness. This is one of the most intricate questions to decide—*when* the child distinguishes its own body, head, hands, &c., from other objects, as belonging to himself. The first time a child says "I" and "me," in the correct sense, it may be considered to have passed the limit. The formation of ideas by associating impressions, as well as the formation of general ideas (*Begriffe*) by uniting similar qualities of different objects, is intellectual work done by the child long before it knows anything of its own individuality. It seems to me that self-consciousness does not arise suddenly, but by degrees, after many experiments have shown the difference between touching his own body and external objects with his little hand.

I have been occupied with psychogenetical problems since nearly four years, continually collecting facts. Should you be able to awaken some interest for these most important investigations (I mean the physiology and psychology of infants), I think the trouble taken would soon be repaid by the results.

I am, sincerely,

DR. WM. PREYER, Professor

P.S.—Perhaps the observations and experiments on the senses (sight, hearing, smell, taste) of new-born animals and infants which I published in *Kosmos* (Zeitschrift herausgegeben von E. Krause), vol. iii. pp. 22–37, 128–132 (1878, Leipzig), may have some little interest. In England Romanes has written very able papers on the development of instinct and intelligence. His address is 18, Cornwall Terrace, Regent's Park, London.

Yours, &c., W. P.

ABNORMAL BAROMETRIC GRADIENT BETWEEN LONDON AND ST. PETERSBURG IN THE SUN-SPOT CYCLE

BEFORE alluding to the subject which forms the heading of the present communication, I must apologise for having allowed some rather serious errors to creep into the figures given for the barometric abnormals of London in my letter to NATURE, vol. xxiii. p. 243. The errors were caused by a friendly computer taking the differences from the mean for each year incorrectly in one or two cases.

I am glad to say however with respect to the relation between the barometric abnormals as there given and the sun-spot numbers, that far from its being vitiated by the corrections which have now been made, they on the contrary considerably strengthen it, as is evident when the following corrected values for the mean cycles are compared with those given in my former letter:—

LONDON

Annual Barometric Abnormals, Mean Cycles

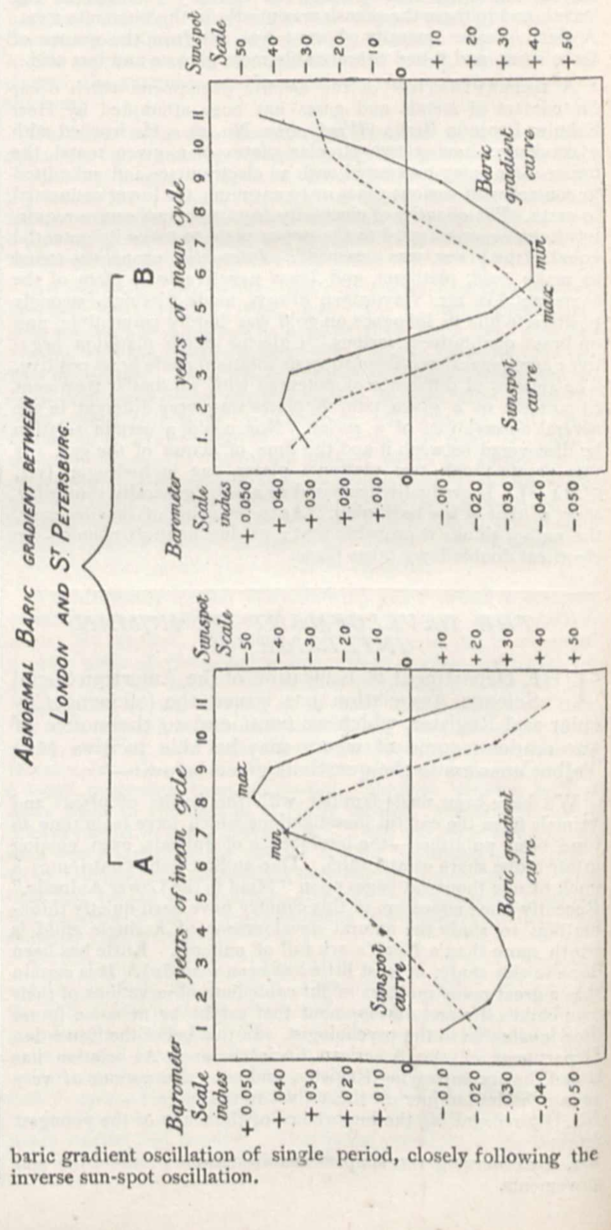
	Maximum years in fifth line. Pressure (1811–77).	Sun-spots (1811–77).	Minimum years in seventh line Pressure (1816–79).	Sun-spots (1816–72).
1.	+0·011	−33·9	−0·006	+23·3
2.	+0·024	−23·4	−0·003	+14·5
3.	+0·017	0·0	−0·002	+ 4·8
4.	−0·003	+28·2	−0·004	− 5·6
5.	−0·011	+43·1	−0·006	−19·0
6.	−0·012	+34·2	−0·002	−32·5
7.	−0·008	+16·8	+0·003	−37·1
8.	±0·000	+ 0·2	+0·020	−25·4
9.	+0·002	−14·2	+0·025	+ 1·8
10.	+0·010	−24·2	+0·010	+30·9
11.	+0·008	−26·3	−0·009	+44·8

If now we take these corrected figures, and subtract from them those given in NATURE, vol. xx. p. 28, for St. Petersburg (reduced to inches), which comprise very nearly the same period, we get for the abnormal annual baric gradient from London to St. Petersburg in each year of the mean cycle, the following figures:—

Abnormal Annual Barometric Gradient between London and St. Petersburg

	(B) Maximum years in fifth line. Pressure. London–St. Petersburg (1811–77). (1822–71). inches.	Sun-spots (1811–77).	(A) Minimum years in seventh line. Pressure. London–St. Petersburg (1816–79). (1822–71). inches.	Sun-spots (1816–72).
1.	+0·032	−33·9	−0·012	+23·3
2.	+ ·038	−23·4	− ·027	+14·5
3.	+ ·036	0·0	− ·033	+ 4·8
4.	+ ·007	+28·2	− ·029	− 5·6
5.	− ·029	+43·1	− ·018	−19·0
6.	− ·040	+34·2	+ ·010	−32·5
7.	− ·040	+16·8	+ ·036	−37·1
8.	− ·025	+ 0·2	+ ·048	−25·4
9.	− ·012	−14·2	+ ·041	+ 1·8
10.	+ ·013	−24·2	+ ·016	+30·9
11.	+ ·043	−26·3	− ·018	+44·8

An inspection of these figures at once reveals the existence of a



baric gradient oscillation of single period, closely following the inverse sun-spot oscillation.

In order to exhibit the constancy of the lag in the occurrence of the gradient variations behind those of the sun-spots, as well as the remarkable similarity in form of the two oscillations, I have reproduced the above figures graphically in the accompanying diagram, in which the baric gradient abnormals are plotted out simultaneously with the *inverted* sun-spot abnormals:—

It will be observed that there is an almost uniform lag in the baric gradient curve behind the inverted sun-spot curve of a little more than a year, while a variation of ·01 inches on the barometer scale corresponds very nearly throughout (allowance being made for the lag) to 10 on the sun-spot scale.

As the strength of the prevailing west and south-west winds of these regions must necessarily depend on the amount of the baric gradient between places on the edge of the European continent like London, and those inland, and to the north as St. Petersburg, there is fair ground for concluding that the west and south-west winds must on the whole be stronger in years of minimum sun-spot than in those of maximum sun-spot.

Some direct evidence in favour of this notion has already been communicated to NATURE by Mr. S. A. Hill and Mr. Ellis of the Greenwich Observatory.

Moreover the amount of variation in the strength of the wind between London and St. Petersburg, following upon the change in the barometric gradient between the two during the cycle, should be enough to cause a *sensible* variation in the character of the weather; for according to Mr. Blanford the mean barometric gradient over the Bay of Bengal during the south-west monsoon is about 0·025 inches in 100 miles.

Now as the distance from London to St. Petersburg is about 1300 miles; in order to maintain a current of air between them throughout the year equal to that of the summer monsoon in the Bay of Bengal, there would have to be a total annual barometric gradient of 0·0325 inches. As the range of the abnormal gradient in the present case amounts to 0·08 inches it should cause a variation in the wind equal to one-fourth that of the monsoon.

For the period 1822-71 the normal mean annual gradient from London to St. Petersburg is + 0·098 inches. The variation of the abnormal is therefore nearly equal to the normal gradient.

Taking the results just obtained with those given by Mr. H. F. Blanford in his article in NATURE, vol. xxi. p. 477, it may be concluded that there is a barometric "see-saw" between Russia and Western Siberia and the Atlantic coasts of Europe, similar to that between the former districts and Indo-Malaysia.

Just as in the latter case the relation will probably be found to be more marked in the winter months, and may also be found to explain some of the numerous facts already ascertained regarding variations in the rainfall, cloud, and temperature of Western Europe, at different epochs of the sun-spot cycle.

E. DOUGLAS ARCHIBALD

CONGRESS OF THE FRENCH LEARNED SOCIETIES

THE session of the Congress of the French Learned Societies has lasted only three days, but has exhibited an unusual amount of interest. Many papers were read in the section of Science presided over by M. Milne-Edwards, the veteran member of the Institute.

M. Alluard summarised the results of rotation of the wind as registered by anemometers at an altitude where it is not to be feared that surface-friction should interfere. The number of rotations from north to south was 113. Of these 83 were in the positive direction, or by east, and only 30 by west; 49 of the 83 positive were continued to the west, and 34 stopped at the south or vicinity; consequently when a wind has come from north to south by east, the greater probability is that it will continue rotating to the west. When it has rotated to the west the probability is even greater that it will continue to the north. Again, of the 49 three-quarter rotations observed not less than 32 were completed, and only 17 stopped at the west and vicinity. The same thing cannot be said of the negative rotations: only 13 were from north to east, and of these only 6 were from north to north by west. These results are a confirmation of Dove's well known law.

General Nansouty, the director of the Pic-du-Midi Observatory, announced that the new buildings on the top of the mountain will soon be ready, and that next winter he will use them for taking readings. It is curious that the last winter has been one of unusual mildness in this exalted altitude.

M. Hébert read a long paper on the formation of cyclones, which he explains by the influence of mountain ranges on the great atmospheric currents loaded with humidity.

M. Vidal presented a photometer based on the action of light on a selenium element of the ordinary construction. M. Vinot, editor of *Le Ciel*, presented a refractor mounted equatorially, of which the price is less than 10*l*., with a magnifying power of 150. M. Joubert gave details on the working of the Trocadéro Popular Observatory, which is now in constant operation, and where lectures on astronomical subjects are delivered regularly.

M. Guillemare read a paper on the use of soleine for lighting purposes. This product has been obtained by the distillation of a number of resinous matters, which have a point of ebullition from 150 to 160 Centigrade and a mean density of 0·860. When they have been freed from every other matter they can be used in a specially-prepared burner. This soleine can be prepared in immense quantities in all countries where pines are abundant.

A number of interesting communications were made on palæontology and zoology, generally advocating Darwinian views.

The final sitting was presided over, as usual, by the Minister of Public Instruction, and took place in the large hall of the Sorbonne. A number of crosses of honour and medals were distributed.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

OXFORD.—The lectures of the summer term commence this week. At the University Museum Prof. Clifton will conduct a class in practical physics and will lecture informally on the use of optical instruments. Mr. Stocker will give an experimental lecture in mechanics, and Mr. V. Jones will lecture on mechanical problems, in continuation of their courses last term. Prof. Odling will continue his course of lectures on organic chemistry, and Mr. Fisher will finish his inorganic course.

At Christ Church Mr. Harcourt lectures on the metals, and Mr. Baynes on the theory of gases. At Balliol Mr. Dixon gives an experimental lecture in elementary physics.

In a Congregation holden on Tuesday, April 27, it was resolved that candidates, not being members of the University, may present themselves at any of the ordinary examinations for Responsions. Last term a statute was passed instituting an examination to take place in the Long Vacation. This examination, which can be passed by candidates before matriculation into the University, is to be passed in lieu of Responsions. The effect of the statute will be that all young men may pass Responsions before they matriculate, and less of their University time will be consumed in getting up school work.

The proposal to designate the unattached students as students of the University Hall was lost by a large majority, 90 voting against the proposal and only 9 for it.

SOCIETIES AND ACADEMIES

LONDON

Chemical Society, April 21.—Dr. Debus in the chair.—It was announced that a ballot for the election of Fellows would take place at the next meeting, May 5.—The following papers were read:—On the distillation of mixtures of carbon disulphide and carbon tetrachloride, by F. D. Brown. The objects of the research were to find the boiling-point of every possible mixture of the two liquids, and the composition of the vapour evolved by any mixture when boiling. Tables and curves giving these results accompany the paper. The author also finds that the composition of the vapour evolved is independent of the pressure under which ebullition takes place.—On the estimation of hydric peroxide by means of potassic permanganate, by W. E. Adeney.—On the oxidation of sulphurous acid, by H. P. Dixon. The author finds that when sulphur dioxide, steam, and oxygen are exposed to a temperature of 100° C. no diminution of volume takes place, and therefore no sulphhuric acid is formed. If the temperature be allowed to fall so that water condenses, a slight contraction in volume is observed.—On the reduction of cinnamic alcohol, by F. Hatton and W. R. Hodgkinson. When this substance is heated to 100° C. for three or four days with sodium amalgam (containing 15 per cent. sodium), and a small quantity of water cinnamene and methylic alcohol are produced.

Entomological Society, April 6.—W. L. Distant, vice-president, in the chair.—One Ordinary and one Honorary Member were elected.—Mr. J. Jenner Weir exhibited an undetermined *Noctua*, apparently allied to the genera *Dicycla*, or *Gortyna*, which was found in a nursery garden at Blackheath in August last.—Mr. R. McLachlan exhibited three rare species of the Neuropterous genus *Dilar*, Ramb.—Rev. A. E. Eaton exhibited a specimen of *Haplophthalmus elegans*, Schöbl., a wood-louse new to the British fauna.—Miss E. A. Ormerod exhibited two termites' nests from British Guiana.—Mr. T. R. Billups exhibited specimens of two rare British insects—*Ichneumon erythræus*, Gr., and *Lasiosomus enervis*, Herr. Schäff.—The Secretary announced the death of Herr J. H. C. Kawall, a well-known entomologist of Courland, at the age of eighty-two.—Mr. R. McLachlan read a description of a new species of *Cordulina* (*Gomphomacromia fallax*) from Ecuador.—Mr. J. B. Bridgman communicated a paper entitled "Some Additions to Mr. Marshall's Catalogue of British *Ichneumonidæ*." Upwards of sixty species (most of which were exhibited to the meeting) were noticed as new to the British fauna, including thirteen new to science.

Meteorological Society, April 20.—Mr. C. Greaves, F.G.S., vice-president, in the chair.—W. H. Goss, F.G.S., and Admiral I. L. Massie were elected Fellows of this Society.—The following papers were read:—On the frequency and duration of rain, by Dr. Wladimir Köppen of Hamburg.—Results of experiments made at the Kew Observatory with Bogen's and George's barometers, by G. M. Whipple, B.Sc., F.R.A.S.—On a discussion of Mr. Eaton's table of the barometric height at London with regard to periodicity, by G. M. Whipple, B.Sc., F.R.A.S.

Anthropological Institute, April 12.—F. W. Rudler, F.G.S., vice-president, in the chair.—The election of Lieut.-Col. R. G. Woodthorpe, R.E., and of Thomas Vincent Holmes, F.G.S., was announced.—Mr. Joseph Lucas read a paper on the ethnological relations of the Gypsies. In tracing back the past history of the races described under the common name of Gypsies we pass through two periods—the first *historical*, dating from A.D. 1414; the second partly historical, partly inferential. This older section formed the subject of Mr. Lucas's paper. The author premised that linguistic evidence shows that the various tribes of Gypsies now scattered over Europe can be referred to several Eastern tribes from India to Persia. The investigation dates back to archæological times, especially in relation to the working of metals and the presence of a large number of pure Sanscrit words in the language of European Gypsies, many of which do not occur in Hindustani. The "archæological" section embraces all that was not included under the several sections—"The Gypsies in Egypt," "Gypsies among the Romans," or "The Dark Ages"; but a good deal of the evidence upon which the archæological conclusions rest runs through those several sections, as well as through sections specially devoted to the names *Zingáro* and *Rom*. It will thus appear that the term "Gypsy" is used by the author in the widest sense as meaning "an Asiatic tribe which has wandered into Europe," though strictly it should mean only those who came by way of Egypt.

PARIS

Academy of Sciences, April 18.—M. Wurtz in the chair.—The following papers were read:—Microscopic inscription of movements observed in physiology, by M. Marey. The accuracy of the curves from M. Marey's instruments has been doubted, on the ground that vibrations proper to the light lever may be added to the physiological movement. He now removes this objection by greatly diminishing the range and velocity of the lever so as to give microscopic curves on smoked glass (which is also moved more slowly). The inertia of the lever becomes negligible. The curves, when examined in the microscope or by projection, are found identical with the others. The method greatly extends the field of phenomena that may be registered, *e.g.* the vibrations of blood in the vessels, which give a sound, produce a distinct microscopic trace. The portable character of the apparatus is an advantage.—On the Eulerian integral of the second species, by M. Gyldén.—On the surface of Kummer with sixteen singular points, by M. Brioschi.—On the action of heat on ammoniated bases, by M. Hofmann.—Report on a memoir of M. Perissé, entitled "Causes which tend to warp the Girders of Iron Bridges, and Means of Calculating these Girders for Resistance of Warping Forces."—On the secondary battery of M. Faure, by M. Reynier. This is an improvement on M. Planté's. M. Faure quickly gives his couples a power of almost unlimited accumulation by covering the lead electrodes with a layer of spongy lead formed and retained thus: The two sheets of lead are each covered with minium or other insoluble oxide of lead, then with a felt envelope held by lead rivets. They are then placed near each other (in spiral, it may be) in acidulated water. The electric current changes the minium to peroxide on the positive electrode, and to reduced lead on the negative. On discharging, the reduced lead is oxidised and the peroxidised lead reduced. A quantity of energy capable of giving 1-horse power for one hour may be had with a Faure battery of 75 kg. The battery, under certain conditions, returns 80 per cent. of the work expended in charging it.—A letter from Ampère to Lacroix was read. It was written when he was Professor in the Lyceum of Lyons, and expresses his enthusiasm for mathematical studies.—On the earthquake of Chio, by M. de Pellissier, Consul-General at Smyrna. The amplitude of the first oscillation, on the afternoon of April 3, was estimated to be between 0·15 m. and 0·20 m. From then till the 5th 250 shocks were felt, thirty or forty of which were capable of throwing down a solid wall. All the oscillations were in the direction east to west. The Governor's palace, of very light construction, but chained throughout at the level of each storey, resisted all the shocks, while the wall inclosing the grounds, 0·70 m. thick, was everywhere thrown down. Smyrna has become a refuge for the wounded.—On Fuchsian functions, by M. Poincaré.—On Abelian functions, by the same.—On a class of functions, the logarithms of which are sums of Abelian intervals of the first and third species, by M. Appell.—On the formulæ of representation of functions (continued), by M. Du Bois-Reymond.—On stellar photography, by Prof. H. Draper. By exposing 140 minutes in the telescope, he has succeeded in photographing stars of magnitude 14·1, 14·2, and 14·7 (Pogson's scale) in the nebula of Orion; the weakest is of the sixteenth magnitude on Herschel's scale. The minimum of visibility for the 9-inch telescope used has been thus nearly reached, and Prof. Draper hopes soon to be able to go still further. The nebula extends over a surface about 15′ in diameter.—Action of electrolysis on toluene, by M. Renard.—Structure and comparative texture of the ink-bag in cephalopoda of the French coasts (continued), by M. Girod. The species observed were *Sepia officinalis*, *Loligo vulgaris*, *Sepiola Rondeleti*, and *Octopus vulgaris*.—On the large dunes of sand of the Sahara, by M. Rolland. These dunes move toward the south-east, and the sum of sand is increased by disaggregation of rocks; but the movement and increase are almost insensible in a generation.

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