THURSDAY, SEPTEMBER 18, 1913.

THE STRUCTURE OF THE ATMOSPHERE IN CLEAR WEATHER.

The Structure of the Atmosphere in Clear Weather: a Study of Soundings with Pilot Balloons. By C. J. P. Cave, M.A. Pp. xii+144. (Cambridge: The University Press, 1912.) Price 10*s*. 6*d*. net.

MR. CAVE'S book is a welcome addition to the valuable contributions of amateurs to the common stock of scientific knowledge, and is the more welcome as the first book on this special subject. The investigation of the upper air is of such interest and the incidental problems which it presents are so numerous, so attractive, and, in these days of flying, so practical, that it is a matter of some surprise that there are not found more men of leisure to follow the notable examples of Prof. Lawrence Rotch and M. Teisserenc de Bort in the investigation of the free atmosphere. Mr. Cave in his introduction refers to the circumstances in which he began the study of the subject. As a matter of history, they can be traced to a letter by the present writer in *The Times* asking for the cooperation of yachtsmen in the exploration of the air over the sea by means of kites. Since that letter appeared we have had to chronicle the division of the atmosphere into two distinct layers, an upper layer, the *stratosphere,* in which there is little or no variation of temperature in the vertical, but sensible variation from day to day, or along the horizontal, and a lower layer, the *troposphere,* in which the variation of temperature is greatest in the vertical and relatively small along the horizontal. At the boundary between the two layers which is found at different heights in different regions, and on different occasions according to the barometric pressure, there is generally a slight inversion in the fall of temperature with height. Ten kilometres may be taken as a rough and ready estimate of the average thickness of the troposphere with the understanding that there is a latitude of three or more kilometres to be allowed in either direction according to circumstances.

With the progress of the general investigation of the upper air attention has been directed especially to the observation of air-currents at different levels by means of pilot balloons watched through theodolite-telescopes of special construction, introduced by M. de Quervain. Mr. Cave's book gives a comprehensive account of the methods and results of work of this character based upon his own experience at Ditcham Park and elsewhere. The apparatus is simple and less expensive than that required for the determination of temperatures:—a balloon which need not be large enough to carry recording instruments, some hydrogen, and accessories, two theodolites to be used simultaneously from two ends of a base for the observation of the altitude and azimuth of the rising balloon at the end of each minute or half minute from the start. One of the theodolites may be dispensed with if the observer knows with reasonable accuracy the rate of ascent of the balloon, and, as appears from one of Mr. Cave's chapters, this condition may be assumed without fear of losing the characteristic features of the ascent. In fact, observations of pilot balloons with one theodolite have been asked for as part of an international enterprise. The reduction of the observations is laborious, as each sounding entails the solution of many triangles, but with the judicious use of a slide rule and tables as described on p. 12, the labour is apparently not intolerable. The results of two hundred soundings in 1907, 1908, and 1909, with one in 1910 involving the solution of 8000 triangles, are given in the book. They are classified according to certain types of structure. For each sounding the velocity and direction of the horizontal motion of the air at each half kilometre are given in tables on pp. 84–107, and they are illustrated by a number of diagrams showing the variation of direction and velocity with height, accompanied by the weather maps which represent the distribution of surface pressure on the occasions of the ascents. A word of praise must here be given for the excellence of the arrangement and printing of the tables and of the diagrams and maps.

The order of the book also deserves remark. Mr. Cave has departed from the usual course in not taking the mean values of all the fish that have come into his net. He has sorted out his catch before submitting it to digestion. In fact, there are, if we recollect rightly, no mean values anywhere in the book. In the present state of our knowledge this decision is a wise one, for until the variations are reduced to those of observation alone, a mean value often conceals more truth than it reveals, and is sometimes actually misleading.

The first step in the discussion is to form a selection of types of structure. These are excellently illustrated by photographs of cardboard models.

The use of pilot balloons is subject to some obvious limitations. There is no little difficulty in pursuing a balloon with a theodolite for great distances. On one favourable occasion Mr. Cave kept a balloon in view until it was forty miles away, but ordinarily a sounding comes to an end by losing sight of the small speck in the field of view of the theodolite either by a trick of eyesight or by the accident of clouds, long before any such distance has been reached. Consequently, the investigation is limited to clear weather, and for the most part to the lower layers of the atmosphere. The lower half of the troposphere, say, up to five kilometres from the surface, is the region specially under observation, but when the sky happens to be clear the investigation can be extended to much greater heights. Mr. Cave gives twelve examples of series of observations beyond 11 kilometres, and one up to 18 kilometres. He is therefore able to devote a chapter to the winds of the upper layer, the stratosphere, and he supports the general conclusion that the wind falls off rapidly as the boundary of the stratosphere is approached and passed, though we must wait to learn whether this result is characteristic of the stratosphere or merely characteristic of the weather when the stratosphere comes under observation.[1]

Useful chapters will be found devoted to methods of observing and their accuracy, and to the rate of ascent of balloons, with an examination of the effect thereupon of the orographical features of the neighbourhood. The author then takes up the meteorological applications of his results. This section takes the form, for the most part, of a study of the relation of the strength and direction of currents aloft to the distribution of pressure and temperature at the surface, and leads up to an important diagram on p. 75 showing the upper winds in relation to a hypothetical distribution of high and low pressure at the surface. The diagram represents increased velocity aloft in the westerly currents of a "low," and in the south-westerly and north-westerly currents of a "high," but a diminished velocity in the easterly wind of a "high." To judge by the text, an unchanging current might have been represented in the more central area where there is little pressure gradient, and certainly a reversal of the north-easterly current on the south-eastern side of a high-pressure area. But the most striking feature of the diagram is a strong north-westerly upper current increasing with height (across the surface isobars and the south-westerly surface winds) from the central region of a "low" to the eastern region of the neighbouring "high." This noteworthy current which must be closely associated with the dynamical structure of the atmosphere is rightly selected as one of the types of structure to which attention is specially called. It is in line with observations of cirrus cloud in front of a low-pressure area.

[1] The falling off of wind with height in the stratosphere can be shown to be a logical consequence of the higher temperature of the region of lower pressure.

The relations to the sequence of weather on many occasions are set out in detail, but the results are not easily generalised except in the special case of the reversal of the current over a north-easterly wind, which is shown in many instances to be the precursor of rain and thunderstorms.

Some attention is given to the relation of the direction and strength of the wind in the upper air to the pressure gradient at the surface, assuming that the gradient wind is tangential to the isobars. As regards direction, there are useful diagrams showing the relation of the gradient directions to the surface winds for the three types of structure, viz.: (1) "solid current," (2) increase of velocity aloft, and (3) decrease of velocity aloft; the last shows the decreasing winds to be limited to cases of surface wind between north and south-east. As regards strength, gradient velocities are calculated from the usual formula:

$$V=\gamma/(2\omega\rho\sin\lambda),$$

and the increase of velocity with height for some situations is attributed to an increase of gradient deduced from the distribution of temperatures in the lowest layers indicated in the published weather-charts.

The increase of gradient is calculated from the surface temperature by a rough and ready formula which, considering the local influences upon temperature and other circumstances, is sufficiently accurate for Mr. Cave's immediate purpose; but it may be useful to give here a more accurate formula, to which that used by Mr. Cave approximates. Neglecting the effect of humidity, which is certainly small and usually unknown, the *increase* of pressure difference in millibars for h metres of height measured from any level is given by the formula:

$$\Delta p_h - \Delta p = 0{\cdot}0342 h \frac{p}{\theta}\left(\frac{\Delta\theta}{\theta} - \frac{\Delta p}{p}\right),$$

where p is the pressure at one place, $p+\Delta p$ that at another on the same level, θ and $\Delta\theta$ are the temperature and temperature difference, and Δp_h is the pressure difference at h metres above the given level.

Near the surface p/θ is approximately equal to 3, so that for the first k kilometres from the surface the formula would become approximately:

$$\Delta p_k - \Delta p_s = 100k\left(\frac{\Delta\theta}{\theta} - \frac{\Delta p}{p}\right).$$

The approximate formula used by Mr. Cave is practically identical with this, except that the term $\Delta p/p$ is omitted. The omitted term may be sufficiently small to be neglected for the surface layers when Δp is not large, because p is numerically of the order of 1000 in that region, but $\Delta p/p$ cannot be neglected in calculations requiring greater accuracy, or in the upper reaches of the atmosphere, where p has a much smaller value because θ does not fall proportionally to the fractional fall of p.

In considering any physical explanation of the structure of the atmosphere, the difference $\Delta p/p-\Delta\theta/\theta$ is an important quantity. In fact, as a rule, it appears that, somewhere or other in a vertical section of the troposphere (where $\Delta\theta$ and Δp are of the same sign), in consequence of the variations in the magnitudes involved, the quantity $\Delta p/p-\Delta\theta/\theta$ *becomes zero and changes sign.* To that curious circumstance is due the dominance of the influence of the stratosphere upon the dynamics of the surface layers, although it only represents about a quarter of the whole mass of the atmosphere. In the stratosphere Δp and $\Delta\theta$ are of opposite signs, and their influences in the production of pressure difference reinforce each other. Hence in the stratosphere, pressure differences are rapidly built up, while in the troposphere changes are capricious and contradictory.

But fortunately these considerations are, so far as can be judged, of little importance in the cases to which Mr. Cave has applied his rough and ready formula, and do not affect the general accuracy of his conclusions.

For the practical study of the dynamics of the atmosphere we are largely dependent upon observations with pilot balloons. They may be taken as supplementing observations of clouds, and, in due time, both must be brought into relation with the observations of pressure and temperature obtained from registering balloons. It is in many ways unfortunate that the track of a registering balloon cannot always be followed by a theodolite or otherwise determined. As it is, we often get our kinematical conditions from one occasion, and our baric and thermic conditions from a different one.

Something may be done to bring the two together by means of observations of cloud-sequence, which can be observed on either occasion. At present these have hardly come within the range of meteorological work. Few observers are effectively conscious of the rapidity of the changes which are indicated by clouds, and which must be the results of the distribution of pressure, temperature, and wind.

In the book before us little is said of the association of cloud-forms and cloud-changes with the variations of the structure of the atmosphere disclosed by pilot balloons, but that part of the subject has great possibilities, and this leads us to express the hope that in a subsequent edition of this interesting work Mr. Cave may be able to give us the benefit of his experience in that direction also.

W. N. SHAW.

SOCIOLOGY AND MEDICINE.

(1) *The Task of Social Hygiene.* By Havelock Ellis. Pp. xv+414. (London: Constable and Co., Ltd. 1912.) Price 8*s*. 6*d*. net.

(2) *The People's Medical Guide: Points for the Patient, Notes for the Nurse, Matter for the Medical Adviser, Succour for the Sufferer, Precepts for the Public.* By Dr. John Grimshaw. Pp. xx+839. (London: J. & A. Churchill. 1912.) Price 8*s*. 6*d*. net.

(1) THE title of this book somewhat masks the nature of its contents, for by "social hygiene" the author means to convey the study of those things which concern the welfare of human beings living in societies. The various chapters, or essays as they practically are, include such varied subjects as the changing status of woman and the woman's movement, eugenics and love, religion and the child, the falling birth-rate, sexual hygiene, war against war, international language, and others. The author generally presents the two points of view, supporting them by quotations and summaries from many sources. The essays are interesting reading, but at the end leave us somewhat in doubt as to what would be for the best, or what the writer considers would be best.

(2) This book covers almost the whole range of subjects comprised within the scope of the practice of medicine and surgery, including the specialities such as diseases of the throat and eye. The information given seems generally to be accurate, is imparted in simple language, and important points are frequently driven home by some terse sentence, *e.g.* "a tooth in the head is worth two on the plate" (p. 57). Some capital sections are given on the management of children, diets and cooking, and physical exercises. The matter does not always seem to come quite in the right place, and simple domestic remedies and treatment may be omitted; for example, that common complaint of children, "child crowing," or "spasmodic croup," is scarcely noticed under children's ailments, but is relegated to the chapter on diseases of the throat, and it is certainly by no means "invariably" associated with rickets.

We think that the compass of the work is somewhat beyond that necessary or desirable for the general public, but the volume would serve as an excellent book of reference for the district nurse, health visitor, missionary, ship's captain, and the like.

R. T. H.

OUR BOOKSHELF.

British Rainfall, 1912. On the Distribution of Rain in Space and Time over the British Isles during the Year 1912, as recorded by more than 5000 Observers in Great Britain and Ireland, and discussed with Articles upon various Branches of Rainfall Work. By Dr. H. R. Mill, assisted by C. Salter. Fifty-second annual volume. Pp. 96+372. (London: E. Stanford, Ltd., 1913.) Price 10*s*.

THE plan of this valuable annual volume remains almost exactly as before; it is well known to many of our readers, and is welcomed by meteorologists and others for its comprehensiveness and the scrupulous care exercised in dealing with matters of detail. Part i. is devoted mainly (1) to the unprecedented rainstorm of August 25–26 in East Anglia, the area being now extended to the whole of England and Wales. The rainfall exceeded 7·5 in. over about sixty-seven square miles, with a small patch where more than 8 in. fell, between Norwich and Brundall. The weight of precipitation over England and Wales is estimated at 4473 million tons. (2) the wettest summer in England and Wales. The rainfall was not exceeded during the last fifty years; in August the amount in south England was more than three times the average over large areas. The general rainfall for June-August was 78 per cent. above the normal. Part ii. deals with the rainfall for the year, and includes the observers' remarks on the weather, with heavy falls and monthly and seasonal rainfall, illustrated by maps. The year was a wet one; expressed in percentages the totals were: England, 123; Wales, 119; Scotland, 111; Ireland, 108; British Isles, 115. Part iii. contains the general tables of total rainfall at 5272 stations; maps of the river-divisions are now given, with the tables for each of the twenty-three large divisions of the country. We notice with regret that this useful and unique organisation is not yet self-supporting, and that the deficit has to be met by the director; further, that owing to the continual strain of the work, Dr. Mill has to take a complete temporary rest, during which time Mr. Mossman, of the Argentine Meteorological Office, will undertake the editorship of the publications.

(1) *Die Süsswasser-Flora Deutschlands, Osterreichs und der Schweiz.* Herausgegeben von Prof. A. Pascher. Hefts. 2, 3, 9, and 10. Price 5, 1.80, 1.50, 4 marks.
(2) *Die Süsswasserfauna Deutschlands eine Exkursions-fauna.* Herausgegeben von Prof. Dr. Brauer. Heft. 14. (Jena: Gustav Fischer, 1912–13.) Price 7 marks.

THESE little monographs on the fresh-water flora and fauna of Germany, Austria, and Switzerland are issued under the general editorship of Prof. Pascher and Prof. Brauer respectively. The series on the fauna is issued in nineteen parts, extending from the Mammalia to the Hydrozoa; that on the flora in sixteen parts, of which the first twelve and part of the thirteenth deal mostly with microscopic forms, the remainder with fungi, mosses, lichens, &c.; a volume on the Protozoa does not seem to be included. The volumes range in price from 1.50 marks to 7 marks, are purchasable separately, and are written by well-known authorities on the subjects of which they treat. Each volume commences with a general description of the particular group dealt with, methods of investigating and preserving the organisms, and a brief list of the principal works and papers on the subject, after which follows a systematic description of species, diagnoses of genera, &c.

(1) These volumes deal with several groups of flagellated micro-organisms (Heft. 2 and 3), including *Euglena*, diatoms (Heft. 10), and the Zygnemales (Heft. 9), *i.e.*, chlorophyl-green, cylindrical-celled algæ, such as *Spirogyra*. All the volumes seem very complete, and that on the diatoms should serve as a very useful handbook on this interesting group of micro-organisms.

(2) This volume deals with the Rotatoria and Gastrotricha. A good account is given of rotifer structure, and the diagnostic tables and descriptions of species are excellent.

All the volumes are profusely illustrated, *e.g.*, no fewer than 379 illustrations are allotted to the diatoms and 474 to the rotifers, many comprising two or more figures.

We believe that these series will be of the greatest service to the field-naturalist and others.

R. T. H.

LETTERS TO THE EDITOR.

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The Nature and Treatment of Cancer and Malaria.

MAY I ask your courtesy for a brief reference to the article by Dr. C. W. Saleeby on the International Medical Congress (NATURE, August 14, pp. 608–9)? Dr. Saleeby notes, that recent research is tending in the direction of the views advanced by me some few years ago. How long will yet elapse before these views as to the germinal origin, trophoblastic (asexual) nature, and enzyme or pancreatic treatment of cancer are "generally accepted" cannot be said. But whenever that time does arrive, mankind in general and medical mankind in particular will have no other refuge against the ravages of cancer than its treatment with genuine strong injections of trypsin and amylopsin. Scientifically, what evidences are there of this? In the first place, among others, three successful cases treated by Major Lamballe were described in my book on cancer, published two years ago. It is quite four years since the patients were treated. Two of them are certainly alive and well, and I believe that this is also so with the third. More recently, I have pointed out, in a paper on the occurrence of dextro-rotatory albumins in organic nature, noticed not long ago in your columns, that the asexual generations, such as the malaria parasite, &c., which induce disease, are the same in nature as cancer-cells, and have foretold their total destruction by the ferments, trypsin and amylopsin. In a memoir, which is about to be published, Major F. W. Lamballe, R.A.M.C., has demonstrated the scientific truth of this. He has shown in a way which must carry complete conviction, that cases of benign and malignant tertian malaria, even very grave cases with cerebral symptoms, in all of which, as his results show, quinine had proved quite useless to stem the disease and to prevent relapses, from *one to three* injections of pancreatic enzymes sufficed not merely to kill all the parasites, but to cure the patient. Relapses in the patients—which had been the rule in very nearly all the cases—did not occur after this brief treatment, and the men (British soldiers) were able to return to duty *at once,* even in some instances on the day of the second or third injection. That is to say—and it is a matter for great scientific satisfaction—the original work, which I began in 1888, has now resulted in the easy and complete conquest of malaria. What this means can be understood from the facts concerning the treatment of malignant malaria, which at present is the rule in the Army. This entails a course of treatment by quinine lasting at least *four months,* and very often, if not always, even then the patient is not cured. But I understand that during this time the soldier is regarded as unfit for active service, and sometimes 25 per cent. of a regiment stationed in the tropics may be in this condition. In contrast to this the pancreatic treatment of malignant malaria in the hands of Major Lamballe entails not more than *three injections,* costing at the outside three shillings, it need not last *two weeks,* and the patient can return to duty at once, and so far as we know is then free from all danger of relapse, but *not* immune to a new infection. The facts here outlined indicate that, properly applied, that which cures malignant malaria *must* cure cancer. J. BEARD.

8 Barnton Terrace, Edinburgh, August 30.

[I AM delighted that my brief reference to Dr. Beard's work should have elicited this interesting letter. He might also have referred to the astonishingly successful treatment of surgical tuberculosis by the pancreatic ferments, which was reported upon by Baetzner in the special tuberculosis number of *The Practitioner* recently. (Being abroad, I cannot give the reference.) When Dr. Beard refers to the malaria parasite as an asexual generation, he must, of course, be thinking of only one-half of its complete reproductive cycle. It would be interesting to make clinical observations as to the action of trypsin and amylopsin upon the sexual and asexual stages of these parasites respectively. As for cancer, I shall never be able to believe that the good results I saw under Dr. Beard's method of treatment six years ago were not causally connected with it. And if it be true, as is now asserted, that the leucocytes, our defenders against morbid cells, normally produce trypsin, perhaps the last has not been heard, after all, of this daring and original theory of Dr. Beard.—C. W. SALEEBY.]

Note on the Dicynodont Vomer.

IN a paper on Dicynodon now being printed by the Royal Society we have already described the bone which Dr. Broom now regards as the "typically mammalian median vomer." It is the bone which he has described previously as the anterior continuation of the basisphenoid, but without recognising the groove on the dorsal surface. No trace of a suture exists between it and the basisphenoid. To us it seemed, as stated in our paper, that the form of this bone, so far from confirming Dr. Broom's views, rendered his interpretation of the grooved bone in Diademodon even more doubtful than before.

That the bone generally recognised as the vomer in Dicynodon had a paired origin we readily admit, and we had already set forth reasons for this view in a paper now in MSS. on the structure of the skull in a small unnamed Dicynodont genus; as we have pointed out in our paper on Dicynodon, the vomer is paired in the guinea-pig, and had probably a paired origin in mammals. IGERNA B. J. SOLLAS.
W. J. SOLLAS.

Oxford, September 6.

An Aural Illusion.

I AM not aware that the following curious particular has been noticed.

If a sounding body has a velocity greater than that of sound in air, it will outstrip its previous sounds as it goes, and leave them to follow in its wake. Let it be supposed that such a body ceases sounding directly it passes an observer. In this case the sound waves of the greatest intensity will be the first to act, and those of the least intensity, the last. Hence the modulation of the sound will be reversed, and will have the character of a *diminuendo,* which we associate with sound that comes from a receding body. In such circumstances, therefore, it would seem to the observer that the source of sound had been travelling away from, instead of towards, him; an illusion touching the swell of the sound, and so the apparent direction of the sounder, quite distinct from those pitch effects which are duly taken cognisance of by Doppler's principle.

NORMAN ALLISTON.

THE NINTH INTERNATIONAL PHYSIOLOGICAL CONGRESS.

THE triennial International Physiological Congress, which was held at Groningen on September 2 to 6, was unanimously voted by those who attended it to be one of the most successful scientific congresses held during the present year. The number of workers engaged in physiological investigation being not very large, the congress, although larger than might have been anticipated, was of manageable size, and since physiologists on the whole are not a fluctuating body, everyone felt at ease and *en famille.*

It would be impossible to speak too highly of the admirable manner in which the president, Prof. Hamburger, with his characteristic precision, provided for the welfare and convenience of all those who attended the congress and who gave demonstrations in the laboratories; these latter are beautifully equipped, and leave nothing to be desired.

To English physiologists this particular physiological congress is of especial interest, since it is now twenty-five years since the congress was founded at the suggestion of the Physiological Society; the late Sir Michael Foster, its first president, was one of those who was most directly connected with its foundation, and it was as a fitting tribute to his labours that his portrait was chosen as the frontispiece for the special Festschrift, edited by Prof. Hamburger and Dr. Laquer. In this volume an excellent *résumé,* arranged according to subject, is given of the work of the congress during the past twenty-five years; this is preceded by the opening address of the president, Prof. Hamburger, at the present congress.

The congress numbered about 400 members, of whom about sixty were British, and the social events were numerous. On September 1 the visitors received in De Harmonie a warm welcome from the Dutch physiologists and the Medical Association of Groningen. The following evening there was a reception in the large hall of the University buildings by the Queen's representative and the Dutch Government. On Wednesday, at the "Sterrebosch" Park, the guests enjoyed the hospitality of the municipality of the town, and on the next day, at the Paterswolder Lake, that of the Ex-Senator M. J. E. Scholten. On Thursday evening there was also an excellent entertainment at the theatre and in De Harmonie. On the last evening a banquet terminated the congress. But the hospitality was not confined to the above-mentioned events; many members enjoyed private hospitality during their stay, and, as stated by Prof. Starling, all the people in the town were so cordial that "we felt that we were not merely the guests of the physiologists, but of every bargee and every tram conductor in the town." There was a special ladies' committee, and several excursions were arranged for the ladies who attended the congress.

To commemorate the occasion of the congress, the Dutch medical journal, *Nederlandsch Tijdschrift voor Geneeskunde,* issued a special number, largely devoted to physiological communications, and to the history of the development of physiology in Holland. The same journal also had a special medal struck, and duplicates were presented to all members of the congress. The medal bore the portrait of the famous Dutch physiologist, Donders, executed by the well-known sculptor Pier Pander; on the back were the words, "Aan de leden van het IX^e Intern. Physiologen Congres. te Groningen, aangeboden door het Nederlandsche Tijdschrift voor Geneeskunde September MCMXIII."

("Offered to the members of the IXth International Physiological Congress in Groningen, by the Nederlandsch Tijdschrift voor Geneeskunde September 1913.")

The demonstrations and communications were very numerous, and it was not possible for one person to see and hear much more than one-third of the whole programme, which occupied most of the mornings and afternoons. The English physiologists contributed largely to the demonstrations, which, as in the meetings of our Physiological Society, had precedence over merely oral communications. The demonstrations of Profs. Starling (heart-lung preparation) and Sherrington (rhythmic reflex produced by antagonising reflex excitation by reflex inhibition) are familiar to English physiologists. A demonstration which attracted much interest was that of Prof. Abel and Dr. Rowntree, of Baltimore; this consisted in an apparatus for what may be termed "vividiffusion," and must be accounted one of the most distinct improvements in physiological technique which have been seen in recent years. The apparatus is called the "artificial glomerulus," and consists of a series of collodion tubes arranged in parallel, and surrounded by warm Ringer's solution; there may be from sixteen to forty-eight tubes in the apparatus, and through this system blood from a chloralosed and hirudinised animal is led. The blood flows out from an artery or vein (*e.g.* from the carotid artery, or from one of the tributaries of the portal vein) through the apparatus, and returns again to the circulation of the animal by a vein (*e.g.* the external jugular vein or the femoral vein). Such a circulation can be carried out under sterile conditions, and may be continued for sixteen hours with ease, and in favourable circumstances for much longer. At intervals the fluid surrounding the collodion "glomerulus" is run off and replaced by fresh Ringer's solution. The solution thus run off will contain all the diffusible substances of the blood other than the saline constituents of Ringer's solution, and on evaporation these may be recovered. In this manner it is possible to detect the presence of substances which are only present in minute traces in the circulating blood; thus, at the end of sixteen hours considerable amounts of amino-acids and of urea can be recovered from the dialysate; sugars and a polypeptide substance are also present. It is worthy of note that, as regards efficiency, the artificial kidney thus made compares very favourably with the animals' own kidneys; thus, when salicylates are given, the artificial glomerulus may excrete as much or more than the kidneys in a given time. It is hoped that a surgical application of this principle will prove of value. The applications of the method to the study of intermediary metabolism are obvious, and interesting results have already been obtained in this direction.

Another interesting demonstration was that of Prof. Benjamin Moore and Dr. Webster, who showed that when carbon dioxide was passed through solutions of such inorganic colloids as uranic oxide or ferric oxide in high dilution, in presence of sunlight or of light from the mercury arc, formaldehyde is formed, and may be detected by Schryver's test. They discussed the relation of this phenomenon to the question of the first appearance of organic matter on the globe.

Dr. Carlson, of Chicago, showed that it is easy to demonstrate on man the presence of rhythmic and of so-called "tetanic" contractions of the walls of the stomach during fasting. For this purpose two long indiarubber tubes are swallowed until their lower ends reach the stomach. One of the tubes serves for the introduction of substances into the stomach, and the other ends in a thin rubber sound which is inflated, and which, when connected with a water manometer, serves to record the contractions of the stomach. Dr. Carlson maintains that these contractions give rise to the sensation of hunger by stimulation of the afferent nerves of the stomach wall, that they are initiated by local automatic mechanisms, and that they are inhibited by various substances which stimulate the nerve endings in the gastric mucosa (gastric juice, acids, alcohol, &c.). Prof. Asher, of Berne, claimed to have demonstrated the presence in the vagus of secretory fibres to the kidneys, and Prof. Noyons, of Liège, showed curves which be believed indicated that there is an antagonism between the internal secretion of the pancreas and adrenalin. The demonstration by Prof. Magnus, of Utrecht, on the influence of the position of the head on the posture in decerebrate rigidity and in normal rabbits was very interesting. The effects are in part due to reflexes from the neck and partly to labyrinthine reflexes.

A novelty of great interest to those interested in painting was the demonstration by Mr. A. H. Munsell, of Boston. This was a quantitative classification of pigment colours based upon measurements by a daylight photometer, Maxwell discs, and the trained discrimination of the painter. The photometer uses the daylight adapted eye, and reads in terms of the Weber-Fechner law.

A somewhat surprising communication came from Prof. Hürthle, of Breslau, who has made a careful study of the variations in pressure and velocity in various arteries during the pulse wave in living animals, and in dead animals perfused by means of an "artificial heart." From these experiments the conclusion is drawn that the arteries are rhythmically contractile, and that their contraction aids the circulation of the blood. It would be interesting to see these experiments repeated with a dead animal perfused from a living heart prepared according to Starling's method.

Many interesting apparatus were shown; among these may be mentioned the now well-known apparatus of Prof. Krogh, of Copenhagen, for the investigation of various respiratory problems; that of Dr. Franz Müller, of Berlin, for the determination of the minute-volume output of the heart in man by a simple application of the nitrous oxide method; the "Kurvenkino" devised by Prof. Straub, of Freiburg, by means of which tracings made on smoked glass in the laboratory may be projected on a screen with realistic effect (apparatus made by Jaquet, of Basel); and the apparatus of Dr. Rohde, of Heidelberg, for the measurement of the oxygen usage of the frog's heart under various conditions of contraction. Dr. Laqueur also showed a projection method for exhibiting the movements of the intestines to a large audience.

The great event of the congress so far as communications are concerned was the closing lecture, which was given by Prof. Pawlow, of St. Petersburg, on "Die Erforschung der höheren Nerventätigkeit," in which he dealt with the subject of conditional reflexes, to which he has devoted the latter third of his active scientific career. Prof. Pawlow is of the opinion that psychology in its present condition can be of little service to the physiologist. The physiologist must remain a physiologist, and must investigate his problems by the recognised methods which have been so fruitful in other fields—he must study the brain as an integrated working organ, and must build up his knowledge independently of the psychologist. The study of reflex action as a purely physiological topic has already yielded valuable results on treatment by the methods of experimental physiology. It is rendered clear by the work of the Pawlow school that we must extend our ideas of reflex action and recognise that besides the elementary function of carrying out ready-formed reflexes, the nervous system has another equally important and fundamental function—that of the formation of new reflexes. It is a generally recognised property of living organisms to adapt themselves to their surroundings, or, in other words, to respond in suitable manner to what were previously indifferent agencies. So far, the reflexes which have been most studied by Pawlow have been those concerned with the secretion of saliva in dogs. Various stimuli can be given so as to affect different sense-organs in different cases, and at the same time the animal is fed, or acid introduced into its mouth; after a short period of such treatment a new reflex has been introduced, for now on application of the accompanying ("conditional") stimulus alone, without the introduction of the food or acid ("unconditional stimulus"), a reflex secretion of saliva occurs. Such reactions have all the characters of the true reflexes, and are equally simple in character, and not, as might seem at first sight, complicated processes grafted on to an unconditional reflex. The intricacy of the conditional reflex is due not to the complex nature of the neural processes involved in the reflex, but to the ease with which it can be inhibited; innumerable conditions in the nervous system itself and in the outer world modify it in this way, and thus investigation of the phenomena is not easy. In close relation to the formation of a conditional reflex is the function of the analysis of the sensations which reach the organism from the outer world, and from which some components are selected by the process of analysis; it is only these selected components which are really utilised in the construction of the new reflex. It seems, then, that by careful study of these reflexes we have the means for acquiring an accurate knowledge of the functional activity of the analysing mechanism. The chief problems which have been investigated are those concerned, firstly, with the origin of the conditional reflexes, and secondly with the mechanism of analysis of sensations. These reflexes can be formed in relation to strong as well as to indifferent stimuli; thus powerful electric stimuli applied to the skin, when the reflex has been trained, do not lead to movements of defence or aggression as is at first the case, but merely to the feeding reflexes of which the flow of saliva is the easiest to follow. This is to be explained as due to the formation of new nerve paths, determined by different excitability of the various nerve centres. Thus the stimulation of bone cannot be made to yield the conditional reflex, since the centres connected with painful stimulation of bone are more powerful than those connected with alimentation.

An important condition for the upbuilding of a conditional reflex is that the particular conditional stimulus used must precede, or accompany, not follow, the unconditional stimulus (food or acid). If it follows the unconditional stimulus, inhibitions are set up, and this inhibition has also been studied. It is also of great importance that the stimulus employed be strictly isolated from incidental ones; in some of the earlier investigations it appeared that the real conditional stimulus was given by the operator himself, by some peculiarity of odour or movements, and not at all by the stimulus which he believed he was employing. For this reason the animals are now always isolated in special rooms, which no person enters during the course of an experiment, all the conditions and observations being controlled from without by means of electrical or pneumatic arrangements.

With regard to the inhibitory processes to which the reflexes are so subject, there may be distinguished three kinds of inhibition. Firstly, we have the inhibition during sleep. Secondly, the inhibition by means of the arrival of other stimuli which have an inhibitory effect (external inhibition). Thirdly, there is a variety which is called "internal inhibition." This is developed as a result of special relations between the conditional and unconditional stimuli by means of which the particular reflex has been prepared. When, for instance, the conditional stimulus is not followed by the customary unconditional one for some time, it becomes converted into an inhibition.

When in the developed reflex the conditional stimulus is not followed (or "confirmed") by the unconditional one, the type of inhibition is called "extinction"; when in working out the reflex the unconditional stimulus only follows some minutes after the conditional, the inhibition which intervenes is called "retardation." "Conditional inhibition" is seen when the conditional stimulus, when accompanied by an indifferent stimulus, is not followed by the unconditional stimulus; lastly, "differential inhibition" is seen in the fact that stimuli approaching closely to the conditional stimulus, and which at the commencement are effective, become eventually inactive. That all these phenomena are really due to inhibition can be shown by the fact that under appropriate conditions the inhibition may be removed, and the effect manifested ("Loshemmung").

The powers of discrimination of the analysors are greatly increased during the development of the reflex, and the conditional stimulus becomes more and more limited and specialised until finally it corresponds to a very small part of the analysing mechanism. Experiments in which definite parts of the cerebral hemispheres have been removed have taught that the cerebrum is the organ which is responsible for the upbuilding of these new reflexes. Want of space renders it impossible to give an account of these experiments on the results of partial extirpation of the cerebrum, since these were given in such brief outline in the lecture that further abstraction is not possible. It is to be hoped, however, that Prof. Pawlow will soon give to the world a book on the subject similar to his famous work on the "Work of the Digestive Glands," since practically all the abundant literature on this new subject is only to be obtained in the Russian language at the present time.

The next International Physiological Congress will be held in Paris in 1916, with Prof. Tigerstedt, of Helsingfors, as President.

C. LOVATT EVANS.

THE DUAB OF TURKESTAN.[1]

IN its opening sentence this book raises an important question, of the propriety of appropriating a word belonging to a language foreign to us and using it, in a sense equally foreign to its native country, in order to express a concept at variance with its original sense. The word *doab,* signifying originally the confluence of two streams, and secondarily the tongue of land between them, has been introduced by Prof. W. M. Davis for a portion of a coastal plain lying between two rivers which never unite, but flow independently to the sea; in the form "duab" it is used by Mr. Rickmers for the country lying between two rivers, the Oxus and Jaxartes, which flow independently into the Sea of Aral, and includes not only the area of plain, which would come under Prof. Davis's use of the word *doab,* but the whole of the mountain region bounded on either side by the main streams of the two rivers.

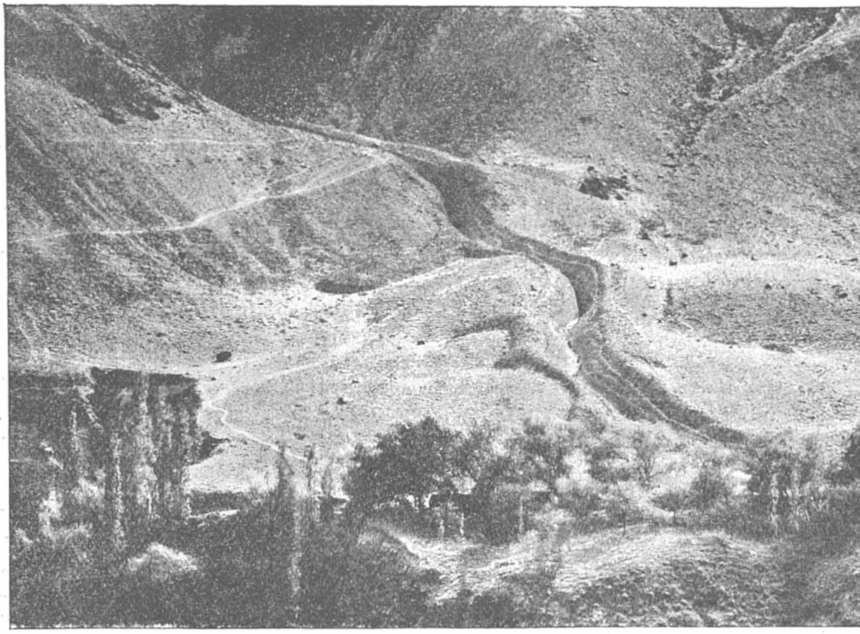


FIG. 1.—Mudspate-track opposite Veshab in the Zarafshan Valley. From "The Duab of Turkestan."

1 "The Duab of Turkestan: A Physiographic Sketch and Account of some Travels." By W. Rickmer Rickmers. Pp. xv+564+plates+maps. (Cambridge: University Press, 1913.) Price 30*s.* net.

For the purpose of a title there is comparatively little objection to this use of the word, but when Mr. Rickmers goes on to coin the adjective "duabic" for the type of scenery developed in this region, a protest must be entered against the needless introduction of a term that conveys no impression of the thing which it represents. The region dealt with presents the results of conditions which are widely spread, and repeated wherever mountains rise high enough, out of what would otherwise be a desert plain, to catch and condense rain from the upper layers of the atmosphere. In such a region the effects of erosion and deposition caused by running water are much more conspicuous than in a moister climate, for the simple reason that they are uncomplicated by the action of other agencies of denudation, with the exception of wind and rapid changes of temperature.

Something, also, must be said in protest against the extremes to which Mr. Rickmers carries the use of metaphor and illustration, too commonly adopted by geographical writers. The use of an illustration by analogy is often illuminating, and may serve to render the result of a complicated series of observations and deductions intelligible to those who have neither need nor leisure to follow the whole course of the research, but quite as often it may merely produce a misleading appearance of understanding where no true explanation is forthcoming, and it is especially dangerous when used, as Mr. Rickmers appears to use it, as a method of research. The description of a range of hills as a "squashed and warty reptile" may recall its appearance to the writer, but does not help the reader; and to talk of the "solid octopus of the Mustagh Pamirs sending out its long, spare tentacles towards the east, gripping the expanses of Tibet, Lop, and Mongolia," is likely to mislead the uninitiated.

Having said this, we must acknowledge the interest of the work as a description of a type of scenery, race, and civilisation absolutely different from anything which the dweller in western Europe or North America will meet with, and would especially commend the description of what the author terms the pamirian type of scenery, which characterises the mountains of central Asia, and his study of the features which distinguish it from the alpine type, met with in the mountains of Europe and western Asia. Something, too, must be said in praise not merely of the number and excellence of the illustrations, but, what is unfortunately more rare, of the judgment with which they have been selected to serve as real illustrations and elucidations of the text.

FIG. 2.—Turrets and Bastions of Conglomerate (Yakhsu). From "The Duab of Turkestan."

BRITISH ASSOCIATION BIRMINGHAM MEETING.

As anticipated, this year's meeting of the British Association has been the largest since 1904. In that year, Cambridge mustered 2789 members, and the Birmingham figure of 2635 does not fall far short of that.

Besides the amplitude of Birmingham's resources in the matter of public institutions, hotel accommodation, and private hospitality, the glorious weather which illumined the proceedings must be given its due share of credit for the success of the gathering. The somewhat unusual combination of the Presidency of the Association and the Principalship of the local University in one person seems, on this occasion, to have been attended with the happiest results. It certainly had a great effect in stimulating local interest, besides attracting a number of the foremost foreign exponents of the exact sciences. The ovation accorded to Madame Curie, more especially by her own sex, was as remarkable as the extraordinary popularity achieved by Prof. Lorentz, who succeeded in making even so formidable a subject as entropy attractive and entertaining to the generality of members.

The fact that the old Mason College, the Midland Institute, and the Technical College are within a stone's throw of each other accounts for the ease with which members could pass from one section to the other. The Geography Section, it is true, was inconvenienced by the noise of the traffic outside the Midland Institute, which is greatest in the morning, but the other sections were admirably housed. Section A had, on the whole, the best lecture theatre, although the applause in the Zoology Section overhead occasionally disconcerted (pleasantly, perhaps) the lecturing physicist below, who sometimes failed to locate the sound.

The arrangements in the reception room met with high commendation on all sides. The spacious Town Hall was an ideal place for the purpose. The ground floor was fitted with luxurious carpets and easy chairs, and a specially built staircase ascended to the gallery, which was laid out in some forty writing compartments. Even at times of the greatest activity, it was reasonably easy to find one's way about, and the local secretaries deserve much credit for the completeness and adequacy of the accommodation afforded.

A still greater triumph of organisation was the Lord Mayor's reception at the Council House, where 3500 visitors had to be marshalled and entertained. Large as was the assemblage, it was quickly distributed over a large space, the new Art Gallery and the Natural History Museum being thrown open for the occasion, so that the sense of crowding conveyed by the hour's procession into the reception chamber was quickly dispelled. The visitors had an agreeable choice between band music; exhibits of British birds, nests, and eggs; dancing; and Dr. Collisson's musical and humorous entertainment in the Council Chamber.

Friday's afternoon reception at Messrs. Cadbury's factory at Bournville gave visitors an interesting though short glimpse of the well-known model village and its various institutions. The spacious recreation ground was the scene of a pretty masque and some maypole dances by the village children which were set off very attractively by the brilliant sunshine, though provision had been made for the event of rain by the erection of three spacious marquees capable of accommodating the whole of the visitors, numbering, as they did, several thousand. The guests were taken back to Birmingham by special trains running by two routes, so that both platforms could be utilised—a fortunate detail which avoided much inconvenience.

Saturday's excursions were a welcome change, both to the visitors who had conscientiously spent their time every morning at the sections, and the secretarial officials, who gained some time to make up arrears of work. It was notable that the foreign visitors preferred the roads that led to Stratford-on-Avon, though Malvern, Kenilworth, Worcester, Coventry, Lichfield, and the Forest of Arden put forth their strongest magnetism, aided by the hospitable efforts of their resident aristocracy. The geological excursions to Nuneaton and Hartshill, the Lickey and Clent Hills, the Wrekin, and the Lutley Valley, the botanical excursion to Sutton, and the excursion to the Burbage experimental farm were of absorbing interest to those specially concerned.

The ecclesiastical services on Sunday were well attended, and the various preachers took pains to emphasise the points in which they agreed with the declarations of prominent speakers from Association chairs. They seemed to find these points unusually numerous. The afternoon saw a large social gathering of physicists and mathematicians at "Mariemont," Sir Oliver Lodge's residence, at which Friday's radiation discussion was informally continued, though not by any means concluded.

The entertainments provided by the local committee for the Monday evening gave members a choice of three. There was St. John Hankin's "Return of the Prodigal" at the Repertory Theatre, Glück's "Orpheus" at the Prince of Wales's Theatre, and a special series of animated pictures dealing with scientific and historical subjects at the Picture House, New Street. The opera was patronised by a brilliant gathering which filled the theatre to overflowing, and Herr Denhof's company gave a new life to the eighteenth century work by symbolic dances and movements which brought out all the tenderness and pathos of the music and the otherwise rather formal acting.

Of the scientific proceedings of the meeting it is difficult to speak with discrimination until a few days have elapsed after its conclusion. The twelve main sections each had their devoted band of special followers, and each had some special occasion on which its proceedings commanded a larger general interest. Thus it was with the radiation discussion in Section A, the fuel and radioactivity discussions in Section B, the joint discussions of Sections D, I, and K on the synthesis of organic matter by inorganic colloids in the presence of sunlight (in which, by the way, Prof. Moore did not by any means succeed in carrying the majority of his colleagues with him, though his exposition was of masterly clearness); the waterways debate in Section F (a matter of vital interest to Birmingham); the anæsthetics report in Section I; and the modern university discussion in Section L.

The great popularity of these discussions has again emphasised the fact that the average member does not come to hear isolated papers of miscellaneous interest. It more than ever throws upon the recorder of each section the responsibility of grouping its papers according to their natural affinities. This seems to be the only chance which the isolated paper has of surviving at the British Association meetings. The numerous facilities now available for publication render it less and less necessary to look to the British Association for a platform from which to announce discoveries, and the practice, so common in the earlier days, is now largely in abeyance. But for bringing like-minded people together to discuss matters of scientific interest, for gauging the trend of opinion on matters of controversy, and for focussing public opinion on matters of importance to the commonweal, the British Association is pre-eminently useful, and the Birmingham gathering has shown that it is not likely to abandon that function for many years to come.

E. E. F.

At an Honorary Degree Congregation of the University of Birmingham, on Thursday, September 11, some distinguished foreigners received honorary degrees, and the following speeches were made by the Principal in presenting them to the Vice-Chancellor:—

Dr. Arrhenius.

Director of the Nobel Institute for Physics and Chemistry, at Stockholm, fellow of the Swedish Academy of Sciences, and foreign member of our own Royal Society. The courageous way in which Dr. Arrhenius applied the theory of electrolytic dissociation to a quantitative study of chemical reactions has profoundly modified the trend of chemical science during the past thirty years, enlarging the scope of chemical investigation, harmonising previously disconnected facts, and bringing an ever-increasing number of chemical phenomena within the range of quantitative and mathematical treatment. He is thus one of the most prominent of the founders of modern physical chemistry, the principles of which he has even applied, with singular success, to some of the most subtle phenomena of organic life. Recently his writings on cosmogony have aroused wide interest; terrestrial electricity and the aurora have yielded to him some of their secrets; and his speculations on worlds in the making are more than interesting and suggestive. A man of genius, and one of the founders of physical chemistry, I present for the honorary degree of doctor of laws, Svante August Arrhenius.

Madame Curie.

The discoverer of radium, director of the Physical Laboratory at the Sorbonne, and member of the Imperial Academy of Sciences at Cracow. All the world knows how Madame Curie (coming from Warsaw as Marie Sklodowska to work in Paris), inspired by the spontaneous radio-activity newly discovered by Becquerel, began in 1896 a metrical examination of the radio-activity of minerals of all kinds; and how, when a uranium residue showed a value larger than could have been expected from its uranium content, she, with exemplary skill and perseverance, worked down some tons of this material (given her by the Austrian Government on the instigation of Prof. Suess), chemically dividing it and retaining always the more radioactive portion, until she obtained evidence first of a new element which she christened polonium, in memory of her own country, and then after months of labour succeeded in isolating a few grains of the other and more permanent substance now so famous—a substance which not only exhibits physical energy in a new form, but is likely to be of service to suffering humanity. Of the metallic base of this substance she determined the atomic weight, finding a place for it in Mendeléeff's series; and with the aid of her husband, whose lamentable death was so great a blow to science, she proceeded to discover many of its singular properties, some of them so extraordinary as to rivet the attention of the world. Subsequent workers engaged in the determination of numbers belonging to either of her special elements, radium and polonium, have sought her advice, and it has proved of the utmost value. I have now the honour of presenting for our honorary degree the greatest woman of science of all time, Marie Sklodowska Curie.

Prof. Dr. Keibel.

The professor of anatomy in the University of Freiburg is the leading authority on the development of man and the embryology of vertebrates. He originated the international standards used in estimating embryological data, and through his classical work on comparative development he has reformed anatomical teaching by the infusion of developmental ideas. His important contributions to anatomical knowledge and method are widely known and highly esteemed, but nowhere more heartily and cordially than in the anatomical department of this University. Held in affectionate esteem by his colleagues, and directing one of the largest schools of anatomy in Germany, this eminent embryologist has been invited to receive our honorary degree, and I present to you Franz Karl Julius Keibel.

Prof. H. A. Lorentz.

To the great school of mathematical physicists of the last and present centuries we in England have proudly contributed even more than our share; but we recognise in the professor of physics in the University of Leyden a contemporary worker worthy to rank with our greatest. Prof. Lorentz has extended the work of Clerk Maxwell into the recently explored region of electrons, and has developed in the molecular direction the Maxwellian theory of electrodynamics. He is a chief authority on the behaviour of material bodies moving through the æther of space, and he has adopted and reduced to order many of the progeny resulting from the fertile marriage of electricity and light. A specially interesting magneto-optic phenomenon, experimentally discovered by his countryman, Zeeman, of Amsterdam, received at his hands its brilliant and satisfying interpretation; an interpretation clinched by predictions of what, on the electric theory of radiation, ought additionally to be observed—predictions which were speedily verified. The Zeeman phenomenon thus interpreted not only gives information as to the intimate structure of various elemental atoms, but, in the hands of the great American astronomers, has shown that sun-spots are electric cyclones of high magnetic power, and is likely further to contribute to our knowledge of solar and stellar constitution. As a great authority on electron theory, and one whose name will for ever be associated with the now nascent electrical theory of matter, I present to you the distinguished mathematical physicist, Hendrik Antoon Lorentz.

Prof. R. W. Wood.

The professor of experimental physics in the Johns Hopkins University of Baltimore is a prolific experimentalist, and one to whose researches in physical optics modern science is greatly indebted. By ingenious use of little-known properties of light, he has explored the structure of molecules, applying the principle of resonance to determine their natural electronic period of vibration. He has, in fact, discovered a new type of spectra in the fluorescent resonance of metallic vapours. What more he has done, in connection with the anomalous absorption of sodium vapour, with specially designed diffraction gratings, and with the application of monochromatic photography to the geology of the moon, it were long to tell; among other things, he anticipated and realised the attainment of regular reflection from a sufficiently dense absorbing vapour; while to the public in America he is known as the inventor of a practical method of thawing frozen pipes by an electric current. The idea of a gigantic telescope in the form of a sunk well, with a revolving pool of mercury at its base to constitute a truly parabolic mirror, may not be a new one, but Prof. Wood has taken it out of the region of the chimerical and shown that it is possible, even if not practically useful. We in this country have reason to envy the splendid resources which the munificence of citizens in America, and of Governments elsewhere, places at the disposal of scientific explorers, and we honour and admire the use which is being made of those resources in every branch of science. As one of the most brilliant experimental physicists of the world, I present for our honorary degree Robert Williams Wood.

Synopsis of grants of money appropriated for scientific purposes by the general committee at the Birmingham meeting September, 1913:—

Section A—Mathematical and Physical Science.

	£	s.	d.			
Prof. H. H. Turner, seismological observations ...	£60	0	0			
Dr. W. N. Shaw, upper atmosphere	25	0	0			
Sir W. Ramsay, constants and numerical data	40	0	0			
Prof. M. J. M. Hill, calculation of mathematical tables	20	0	0			
Lieut.-Col. A. Cunningham, copies of the "Binary Canon" for presentation ...	5	0	0			
				£150	0	0

Section B—Chemistry.

	£	s.	d.			
Dr. W. H. Perkin, study of hydro-aromatic substances	15	0	0			
Prof. H. E. Armstrong, dynamic isomerism ...	25	0	0			
Prof. F. S. Kipping, transformation of aromatic nitroamines	15	0	0			
A. D. Hall, plant enzymes ...	25	0	0			
Prof. W. J. Pope, correlation of crystalline form with molecular structure ...	25	0	0			
Prof. H. E. Armstrong, solubility phenomena	15	0	0			
				£120	0	0

Section C—Geology.

	£	s.	d.			
R. H. Tiddeman, erratic blocks	5	0	0			
Prof. P. F. Kendall, list of characteristic fossils ...	5	0	0			
Dr. A. Strahan, Ramsay Island, Pembroke	10	0	0			
Prof. Grenville Cole, Old Red Sandstone of Kiltorcan	10	0	0			
G. Barrow, trias of western midlands	10	0	0			
Prof. W. W. Watts, sections in Lower Palæozoic rocks	15	0	0			
				£55	0	0

Section D—Zoology.

	£	s.	d.			
Dr. A. E. Shipley, Belmullet Whaling Station	20	0	0			
Dr. Chalmers Mitchell, nomenclator animalium ...	50	0	0			
S. F. Harmer, Antarctic whaling industry	90	0	0			
				£160	0	0

Section E—Geography.

	£	s.	d.			
Prof. J. L. Myres, maps for school and university use...	40	0	0			
Prof. H. N. Dickson, tidal currents in Moray and adjacent firths	40	0	0			
				£80	0	0

Section G—Engineering.

	£	s.	d.			
Sir W. H. Preece, gaseous explosions	50	0	0			
Prof. J. Perry, stress distributions	50	0	0			
				£100	0	0

Section H—Anthropology.

	£	s.	d.			
Dr. R. Munro, Glastonbury Lake Village	20	0	0			
Sir C. H. Read, age of stone circles	20	0	0			
Dr. R. Munro, artificial islands in Highland lochs	5	0	0			
Prof. G. Elliot Smith, physical character of ancient Egyptians	34	16	6			
Prof. J. L. Myres, anthropometric investigations in Cyprus	50	0	0			
Prof. W. Ridgeway, Roman sites in Britain	20	0	0			
Dr. R. R. Marett, Palæolithic site in Jersey	50	0	0			
				£199	16	6

Section I—Physiology.

	£	s.	d.			
Prof. E. A. Schäfer, the ductless glands	35	0	0			
Prof. A. D. Waller, anæsthetics	20	0	0			
Prof. J. S. Macdonald, calorimetric observations ...	40	0	0			
Prof. C. S. Sherrington, mammalian heart	30	0	0			
				£125	0	0

Section K—Botany.

	£	s.	d.			
Prof. F. J. Oliver, structure of fossil plants	15	0	0			
Prof. A. C. Seward, Jurassic flora of Yorkshire	5	0	0			
Prof. F. Keeble, flora of peat of Kennet Valley	15	0	0			
A. G. Tansley, vegetation of Ditcham Park	20	0	0			
Prof. F. F. Blackman, physiology of heredity	30	0	0			
Prof. F. O. Bower, renting of Cinchona Botanic Station in Jamaica	25	0	0			
Prof. W. Bateson, breeding experiments with Œnotheras	20	0	0			
				£130	0	0

Section L—Education.

Prof. J. J. Findlay, mental and physical factors ...	30 0 0
Dr. G. A. Auden, influence of school books on eyesight	15 15 3
Sir H. Miers, Number, &c., of scholarships, &c., held by university students ...	5 0 0
Myers, Dr. C. S., binocular combination of kinematograph pictures	10 0 0
Prof. J. A. Green, character and maintenance of museums	10 0 0
	£70 15 3

Corresponding Societies Committee.

W. Whitaker, for preparation of report	25 0 0
	£25 0 0
Total	£1215 11 9

SECTION A.

MATHEMATICS AND PHYSICS.

OPENING ADDRESS BY H. F. BAKER, SC.D., F.R.S., PRESIDENT OF THE SECTION.

The Place of Pure Mathematics.

IT is not a very usual thing for the opening address of this section to be entrusted to one whose main energies have been devoted to what is called pure mathematics; but I value the opportunity in order to try to explain what, as I conceive it, the justification of the pure mathematician is. You will understand that in saying this I am putting myself in a position which belongs to me as little by vocation as by achievement, since it was my duty through many years to give instruction in all the subjects usually regarded as mathematical physics, and it is still my duty to be concerned with students in these subjects. But my experience is that the pure mathematician is apt to be regarded by his friends as a trifler and a visionary, and the consciousness of this becomes in time a paralysing dead-weight. I think that view is founded on want of knowledge.

Of course, it must be admitted that the mathematician, as such, has no part in those public endeavours that arise from the position of our Empire in the world, nor in the efforts that must constantly be made for social adjustment at home. I wish to make this obvious remark. For surely the scientific man must give his time and his work in the faith of at least an intellectual harmony in things; and he must wish to know what to think of all that seems out of gear in the working of human relations. His own cup of contemplation is often golden; he marks that around him there is fierce fighting for cups that are earthen, and largely broken; and many there are that go thirsting. And, again, the mathematician is as sensitive as others to the marvel of each recurring springtime, when, year by year, our common mother seems to call us so loudly to consider how wonderful she is, and how dependent we are, and he is as curious as to the mysteries of the development of living things. He can draw inspiration for his own work, as he views the spectacle of a starry night, and sees

> How the floor of heaven
> Is thick inlaid with patines of bright gold.
> Each orb, the smallest, in his motion, sings,

but the song, once so full of dread, how much it owes to the highest refinements of his craft, from at least the time of the Greek devotion to the theory of conic sections; how much, that is, to the harmony that is in the human soul. Yet the mathematician bears to the natural observer something of the relation which the laboratory botanist has come to bear to the field naturalist. Moreover, he is shut off from inquiries which stir the public imagination; when he looks back the ages over the history of his own subject, the confidence of his friends who study heredity and teach eugenics arouses odd feelings in his mind; if he feels the fascination which comes of the importance of such inquiries, he is also prepared to hear that the subtlety of Nature grows with our knowledge of her. Doubtless, too, he wishes he had some participation in the discovery of the laws of wireless telegraphy, or had something to say in regard to the improvement of internal-combustion engines or the stability of aëroplanes; it is little compensation to remember, though the mathematical physicist is his most tormenting critic, what those of his friends who have the physical instinct used to say on the probable development of these things, however well he may recall it.

But it is not logical to believe that they who are called visionary because of their devotion to creatures of the imagination can be unmoved by these things. Nor is it at all just to assume that they are less conscious than others of the practical importance of them, or less anxious that they should be vigorously prosecuted.

Why is it, then, that their systematic study is given to other things, and not of necessity, and in the first instance, to the theory of any of these concrete phenomena? This is the question I try to answer. I can only give my own impression, and doubtless the validity of an answer varies as the accumulation of data, made by experimenters and observers, which remains unutilised at any time.

The reason, then, is very much the same as that which may lead a man to abstain from piecemeal indiscriminate charity in order to devote his attention and money to some well-thought-out scheme of reform which seems to have promise of real amelioration. One turns away from details and examples, because one thinks that there is promise of fundamental improvement of methods and principles. This is the *argumentum ad hominem*. But there is more than that. The improvement of general principles is arduous, and if undertaken only with a view to results may be ill-timed and disappointing. But as soon as we consciously give ourselves to the study of universal methods for their own sake another phenomenon appears. The mind responds, the whole outlook is enlarged, infinite possibilities of intellectual comprehension, of mastery of the relations of things, hitherto unsuspected, begin to appear on the mental horizon. I am well enough aware of the retort to which such a statement is open. But, I say, interpret the fact as you will, our intellectual pleasure in life cometh not by might nor by power—arises, that is, most commonly, not of set purpose—but lies at the mercy of the response which the mind may make to the opportunities of its experience. When the response proves to be of permanent interest—and for how many centuries have mathematical questions been a fascination?—we do well to regard it. Let us compare another case which is, I think, essentially the same. It may be that early forms of what now is specifically called art arose with a view to applications; I do not know. But no one will deny that art, when once it has been conceived by us, is a worthy object of pursuit; we know by a long trial that we do wisely to yield ourselves to a love of beautiful things, and to the joy of making them. Well, pure mathematics, as such, *is* an art, a creative art. If its past triumphs of achievement fill us with wonder, its future scope for invention is exhaustless and open to all. It is also a science. For the mind of man is one; to scale the peaks it spreads before the explorer is to open ever new prospects of possibility for the formulation of laws of nature. It resources have been tested by the experience of generations; to-day it lives and thrives and expands and wins the life-service of more workers than ever before.

This, at least, is what I wanted to say, and I have said it with the greatest brevity I could command. But may I dare attempt to carry you further? If this seems fanciful, what will you say to the setting in which I would wish to place this point of view? And yet I feel bound to try to indicate something more, which may be of wider appeal. I said a word at starting as to the relations of science to those many to whom the message of our advanced civilisation is the necessity, above all things, of getting bread. Leaving this aside, I would make another reference. In our time old outlooks have very greatly changed; old hopes, disregarded perhaps because undoubted, have very largely lost their sanction, and given place to earnest questionings. Can anyone who watches doubt that the courage to live is in some danger of being swallowed up in the anxiety to acquire? May it not be, then, that it is good for us to realise, and to confess, that the pursuit of things that are beautiful, and the achievement of intellectual things that bring the joy of overcoming, is at least as demonstrably justifiable as the many other things that fill the lives of men? May it not be that a wider recognition of this would be of some general advantage at present? Is it not even possible that to bear witness to this is one of the uses of the scientific spirit? Moreover, though the pursuit of truth be a noble aim, is it so new a profession; are we so sure that the ardour to set down all the facts without extenuation is, unassisted, so continuing a purpose? May science itself not be wise to confess to what is its own sustaining force?

Such, ladies and gentlemen, in crude, imperfect phrase, is the *apologia*. If it does not differ much from that which workers in other ways would make, it does, at least, try to represent truly one point of view, and it seems to me specially applicable to the case of pure mathematics. But you may ask: What, then, is this subject? What can it be about if it is not primarily directed to the discussion of the laws of natural phenomena? What kind of things are they that can occupy alone the thoughts of a lifetime? I propose now to attempt to answer this, most inadequately, by a bare recital of some of the broader issues of present interest—though this has difficulties, because the nineteenth century was of unexampled fertility in results and suggestions, and I must be as little technical as possible.

Precision of Definitions.

First, in regard to two matters which illustrate how we are forced by physical problems into abstract inquiries. It is a constantly recurring need of science to reconsider the exact implication of the terms employed; and as numbers and functions are inevitable in all measurement, the precise meaning of number, of continuity, of infinity, of limit, and so on, are fundamental questions; those who will receive the evidence can easily convince themselves that these notions have many pitfalls. Such an imperishable monument as Euclid's theory of ratio is a familiar sign that this has always been felt. The last century has witnessed a vigorous inquiry into these matters, and many of the results brought forward appear to be new; nor is the interest of the matter by any means exhausted. I may cite, as intelligible to all, such a fact as the construction of a function which is continuous at all points of a range, yet possesses no definite differential coefficient at any point. Are we sure that human nature is the only continuous variable in the concrete world, assuming it be continuous, which can possess such a vacillating character? Or I may refer to the more elementary fact that all the rational fractions, infinite in number, which lie in any given range, can be enclosed in intervals the aggregate length of which is arbitrarily small. Thus we could take out of our life all the moments at which we can say that our age is a certain number of years, and days, and fractions of a day, and still have appreciably as long to live; this would be true, however often, to whatever exactness, we named our age, provided we were quick enough in naming it. Though the recurrence of these inquiries is part of a wider consideration of functions of complex variables, it has been associated also with the theory of those series which Fourier used so boldly, and so wickedly, for the conduction of heat. Like all discoverers, he took much for granted. Precisely how much is the problem. This problem has led to the precision of what is meant by a function of real variables, to the question of the uniform convergence of an infinite series, as you may see in early papers of Stokes, to new formulation of the conditions of integration and of the properties of multiple integrals, and so on. And it remains still incompletely solved.

Calculus of Variations.

Another case in which the suggestions of physics have caused grave disquiet to the mathematicians is the problem of the variation of a definite integral. No one is likely to underrate the grandeur of the aim of those who would deduce the whole physical history of the world from the single principle of least action. Everyone must be interested in the theorem that a potential function, with a given value at the boundary of a volume, is such as to render a certain integral, representing, say, the energy, a minimum. But in that proportion one desires to be sure that the logical processes employed are free from objection. And, alas! to deal only with one of the earliest problems of the subject, though the finally sufficient conditions for a minimum of a simple integral seemed settled long ago, and could be applied, for example, to Newton's celebrated problem of the solid of least resistance, it has since been shown to be a general fact that such a problem cannot have any definite solution at all. And, although the principle of Thomson and Dirichlet, which relates to the potential problem referred to, was expounded by Gauss, and accepted by Riemann, and remains to-day in our standard treatise on natural philosophy, there can be no doubt that, in the form in which it was originally stated, it proves just nothing. Thus a new investigation has been necessary into the foundations of the principle. There is another problem, closely connected with this subject, to which I would allude: the stability of the solar system. For those who can make pronouncements in regard to this I have a feeling of envy; for their methods, as yet, I have a quite other feeling. The interest of this problem alone is sufficient to justify the craving of the pure mathematician for powerful methods and unexceptionable rigour.

Non-Euclidean Geometry.

But I turn to another matter. It is an old view, I suppose, that geometry deals with facts about which there can be no two opinions. You are familiar with the axiom that, given a straight line and a point, one and only one straight line can be drawn through the point parallel to the given straight line. According to the old view the natural man would say that this is either true or false. And, indeed, many and long were the attempts made to justify it. At length there came a step which to many probably will still seem unintelligible. A system of geometry was built up in which it is assumed that, given a straight line and a point, an infinite number of straight lines can be drawn through the point, in the plane of the given line, *no one* of which meets the given line. Can there, then, one asks at first, be two systems of geometry, both of which are true, though they differ in such an important particular? Almost as soon believe that there can be two systems of laws of nature, essentially differing in character, both reducing the phenomena we observe to order and system —a monstrous heresy, of course! I will only say that, after a century of discussion we are quite sure that many systems of geometry are possible, and true; though not all may be expedient. And if you reply that a geometry is useful for life only in proportion as it fits the properties of concrete things, I will answer, first, are the heavens not then concrete? And have we as yet any geometry that enables us to form a consistent logical idea of furthermost space? And, secondly, that the justification of such speculations is the interest they evoke, and that the investigations already undertaken have yielded results of the most surprising interest.

The Theory of Groups.

To-day we characterise a geometry by the help of another general notion, also, for the most part, elaborated in the last hundred years, by means of its group. A group is a set of operations which is closed, in the sense that the performance of any two of these operations in succession is equivalent to another operation of the set, just as the result of two successive movements of a rigid body can be achieved by a single movement. One of the earliest conscious applications of the notion was in the problem of solving algebraic equations by means of equations of lower order. An equation of the fourth order can be solved by means of a cubic equation, because there exists a rational function of the four roots which takes only three values when the roots are exchanged in all possible ways. Following out this suggestion for an equation of any order, we are led to consider, taking any particular rational function of its roots, what is the group of interchanges among them which leaves this function unaltered in value. This group characterises the function, all other rational functions unaltered by the same group of interchanges being expressible rationally in terms of this function. On these lines a complete theory of equations which are soluble algebraically can be given. Anyone who wishes to form some idea of the richness of the landscape offered by pure mathematics might do worse than make himself acquainted with this comparatively small district of it. But the theory of groups has other applications. It may be interesting to refer to the circumstance that the group of interchanges among four quantities which leave unaltered the product of their six differences is exactly similar to the group of rotations of a regular tetrahedron the centre of which is fixed, when its corners are interchanged among themselves. Then I mention the historical fact that the problem of ascertaining when that well-known linear differential equation called the hypergeometric equation has all its solutions expressible in finite terms as algebraic functions, was first solved in connection with a group of similar kind. For any linear differential equation it is of primary importance to consider the group of interchanges of its solutions when the independent variable, starting from an arbitrary point, makes all possible excursions, returning to its initial value. And it is in connection with this consideration that one justification arises for the view that the equation can be solved by expressing both the independent and dependent variables as single-valued functions of another variable. There is, however, a theory of groups different from those so far referred to, in which the variables can change continuously; this alone is most extensive, as may be judged from one of its lesser applications, the familiar theory of the invariants of quantics. Moreover, perhaps the most masterly of the analytical discussions of the theory of geometry has been carried through as a particular application of the theory of such groups.

The Theory of Algebraic Functions.

If the theory of groups illustrates how a unifying plan works in mathematics beneath bewildering detail, the next matter I refer to well shows what a wealth, what a grandeur, of thought may spring from what seem slight beginnings. Our ordinary integral calculus is well-nigh powerless when the result of integration is not expressible by algebraic or logarithmic functions. The attempt to extend the possibilities of integration to the case when the function to be integrated involves the square root of a polynomial of the fourth order, led first, after many efforts, among which Legendre's devotion of forty years was part, to the theory of doubly-periodic functions. To-day this is much simpler than ordinary trigonometry, and, even apart from its applications, it is quite incredible that it should ever again pass from being among the treasures of civilised man. Then, at first in uncouth form, but now clothed with delicate beauty, came the theory of general algebraical integrals, of which the influence is spread far and wide; and with it all that is systematic in the theory of plane curves, and all that is associated with the conception of a Riemann surface. After this came the theory of multiple-periodic functions of any number of variables, which, though still very far indeed from being complete, has, I have always felt, a majesty of conception which is unique. Quite recently the ideas evolved in the previous history have prompted a vast general theory of the classification of algebraical surfaces according to their essential properties, which is opening endless new vistas of thought.

Theory of Functions of Complex Variables: Differential Equations.

But the theory has also been prolific in general principles for functions of complex variables. Of greater theories, the problem of automorphic functions alone is a vast continent still largely undeveloped, and there is the incidental problem of the possibilities of geometry of position in any number of dimensions, so important in so many ways. But, in fact, a large proportion of the more familiar general principles, taught to-day as theory of functions, have been elaborated under the stimulus of the foregoing theory. Besides this, however, all that precision of logical statement of which I spoke at the beginning is of paramount necessity here. What exactly is meant by a curve of integration, what character can the limiting points of a region of existence of a function possess, how even best to define a function of a complex variable, these are but some obvious cases of difficulties which are very real and pressing to-day. And then there are the problems of the theory of differential equations. About these I am at a loss what to say. We give a name to the subject, as if it were one subject, and I deal with it in the fewest words. But our whole physical outlook is based on the belief that the problems of nature are expressible by differential equations; and our knowledge of even the possibilities of the solutions of differential equations consists largely, save for some special types, of that kind of ignorance which, in the nature of the case, can form no idea of its own extent. There are subjects the whole content of which is an excuse for a desired solution of a differential equation; there are infinitely laborious methods of arithmetical computation held in high repute of which the same must be said. And yet I stand here to-day to plead with you for tolerance of those who feel that the prosecution of the theoretic studies, which alone can alter this, is a justifiable aim in life! Our hope and belief is that over this vast domain of differential equations the theory of functions shall one day rule, as already it largely does, for example, over linear differential equations.

Theory of Numbers.

In concluding this table of contents, I would also refer, with becoming brevity, to the modern developments of theory of numbers. Wonderful is the fascination and the difficulty of these familiar objects of thought—ordinary numbers. We know how the great Gauss, whose lynx eye was laboriously turned upon all the physical science of his time, has left it on record that in order to settle the law of a plus or minus sign in one of the formulæ of his theory of numbers he took up the pen every week for four years. In these islands perhaps our imperial necessities forbid the hope of much development of such a theoretical subject. But in the land of Kummer and Gauss and Dirichlet the subject to-day claims the allegiance of many eager minds. And we can reflect that one of the latest triumphs has been with a problem known by the name of our English senior wrangler, Waring—the problem of the representation of a number by sums of powers.

Ladies and gentlemen, I have touched only a few of the matters with which pure mathematics is concerned. Each of those I have named is large enough for one man's thought; but they are interwoven and interlaced in indissoluble fashion and form one mighty whole, so that to be ignorant of one is to be weaker in all. I am not concerned to depreciate other pursuits, which seem at first sight more practical; I wish only, indeed, as we all do, it were possible for one man to cover the whole field of scientific research; and I vigorously resent the suggestion that those who follow these studies are less careful than others of the urgent needs of our national life. But pure mathematics is not the rival, even less is it the handmaid, of other branches of science. Properly pursued, it is the essence and soul of them all. It is not for them; they are for it; and its results are for all time. No man who has felt its fascination can be content to be ignorant of any manifestation of regularity and law, or can fail to be stirred by all the need of adjustment of our actual world.

And if life is short, if the greatest magician, joining with the practical man, reminds us that, like this vision,

> The cloud-capp'd towers, the gorgeous palaces,
> The solemn temples, the great globe itself,
> Yea, all which it inherit, shall dissolve
> And . . . leave not a rack behind,

we must still believe that it is best for us to try to reach the brightest light. And all here must believe it; for else—no fact is more firmly established—we shall not study science to any purpose.

But that is not all I want to say, or at least to indicate. I have dealt so far only with proximate motives; to me it seems demonstrable that a physical science that is conscientious requires the cultivation of pure mathematics; and the most mundane of reasons seem to me to prompt the recognition of the æsthetic outlook as a practical necessity, not merely a luxury, in a successful society. Nor do I want to take a transcendental ground. Every schoolboy, I suppose, knows the story of the child born, so small, if I remember aright, that he could be put into a quart pot, in a farmhouse on the borders of Lincolnshire—it was the merest everyday chance. By the most incalculable of luck his brain-stuff was so arranged, his parts so proportionately tempered, that he became Newton, and taught us the laws of the planets. It was the blindest concurrence of physical circumstances; and so is all our life. Matter in certain relations to itself, working by laws we can examine in the chemical laboratory, produces all these effects, produces even that state of brain which accompanies the desire to speak of the wonder of it all. And the same laws will inevitably hurl all into confusion and darkness again; and where will all our joys and fears, and all our scientific satisfaction, be then?

As students of science, we have no right to shrink from this point of view; we are pledged to set aside prepossession and dogma, and examine what seems possible, wherever it may lead. Even life itself may be mechanical, even the greatest of all things, even personality, may some day be resoluble into the properties of dead matter, whatever that is. We can all see that its coherence rises and falls with illness and health, with age and physical conditions. Nor, as it seems to me, can anything but confusion of thought arise from attempts to people our material world with those who have ceased to be material.

An argument could perhaps be based on the divergence, as the mathematician would say, of our comprehension of the properties of matter. For though we seem able to summarise our past experiences with ever-increasing approximation by means of fixed laws, our consciousness of ignorance of the future is only increased thereby. Do we feel more, or *less,* competent to grasp the future possibilities of things, when we can send a wireless message 4000 miles, from Hanover to New Jersey?

Our life is begirt with wonder, and with terror. Reduce it by all means to ruthless mechanism, *if you can;* it will be a great achievement. But it can make no sort of difference to the fact that the things for which we live are spiritual. The rose is no less sweet because its growth is conditioned by the food we supply to its roots. It is an obvious fact, and I ought to apologise for remarking it, were it not that so much of our popular science is understood by the hasty to imply an opposite conclusion. If a chemical analysis of the constituents of sea-water could take away from the glory of a mighty wave breaking in the sunlight, it would still be true that it was the mind of the chemist which delighted in finding the analysis. Whatever be its history, whatever its physical correlations, it is an undeniable fact that the mind of man has been evolved; I believe that is the scientific word. You may speak of a continuous upholding of our material framework from without; you may ascribe fixed qualities to something you call matter; or you may refuse to be drawn into any statement. But anyway, the fact remains that the precious things of life are those we call the treasures of the mind. Dogmas and philosophies, it would seem, rise and fall. But gradually accumulating throughout the ages, from the earliest dawn of history, there is a body of doctrine, a reasoned insight into the relations of exact ideas, painfully won and often tested. And this remains the main heritage of man; his little beacon of light amidst the solitudes and darknesses of infinite space; or, if you prefer, like the shout of children at play together in the cultivated valleys, which continues from generation to generation.

Yes, and continues for ever! A universe which has the potentiality of becoming thus conscious of itself is not without something of which that which we call memory is but an image. Somewhere, somehow, in ways we dream not of, when you and I have merged again into the illimitable whole, when all that is material has ceased, the faculty in which we now have some share, shall surely endure; the conceptions we now dimly struggle to grasp, the joy we have in the effort, these are but part of a greater whole. Some may fear, and some may hope, that they and theirs shall not endure for ever. But he must have studied nature in vain who does not see that our spiritual activities are inherent in the mighty process of which we are part; who can doubt of their persistence.

And, on the intellectual side, of all that is best ascertained, and surest, and most definite, of these; of all that is oldest and most universal; of all that is most fundamental and far-reaching, of these activities, pure mathematics is the symbol and the sum.

SECTION B.

CHEMISTRY.

OPENING ADDRESS BY PROF. W. P. WYNNE, D.SC., F.R.S., PRESIDENT OF THE SECTION.

WHEN the present position of education in Birmingham is considered, the transformation effected since the 'seventies is little short of marvellous. Five-and-thirty years ago, when I became an evening student, classes conducted by the Midland Institute met the demand for arts and science subjects; now a University—venerable in comparison with all civic universities save the Victoria University of Manchester—exists to provide instruction in every branch of learning. The spacious building in which we meet—already too small for the demands made on it—is the lineal descendant of that part of the Midland Institute which formerly was used for evening class instruction in science, organised in connection with the science and art department, and financed largely by the system of payment on results; this large lecture theatre replaces the small and inconvenient class-room in which the teaching of chemistry and physics under Mr. Woodward was carried on. Payment on results is obsolete, and the "May" examinations on which it was based have almost disappeared, assessment by inspection now replacing both; nevertheless, it is more than doubtful whether any other system—in the circumstances of the time—could have spread so widely a knowledge of science among the people, or prepared the way for the Technical Instruction Act, and that appreciation of the value of scientific training for industrial pursuits, which is exemplified by the provision through municipal agencies of technical schools in the industrial centres of this country. I sometimes think the Science and Art Department, and those great men, Sir John Donnelly and Prof. Huxley, who did much to shape its attitude towards science instruction in evening classes and in the science schools at South Kensington,[1] have received something less than their share of credit for pioneering work which finds its fruition in well-equipped institutions like this, and in the enhanced position which science holds to-day in the estimation of our countrymen. In those far-off times, before the foundation-stone of Mason College was laid, such evening classes in Birmingham provided the only means by which instruction in science, or scholarships to South Kensington, could be obtained. It is not unfitting, therefore, that I—a product of the system—should acknowledge here the obligation under which I stand both to the Midland Institute and to the Science and Art Department for providing the ladder by which I have risen, however undeservedly, to the honourable position of president of this section.

The historian of our times will not fail to note some of the consequences which have followed the application of science to industry, possibly also some of the educational results which have followed the development of science teaching in schools of all grades. Except from one point of view these need not concern us now as they fall, the one in so far as chemistry is concerned, into the province of the Society of Chemical Industry, the other mainly within the purview of Section L. This bringing of chemistry to the people has aroused a widespread interest in some aspects of the subject, of which the Press has not been slow to take note. Not even the heuristic method can hide from the schoolboy the fact that certain fundamental conceptions are accepted which do not admit of proof, such as the indivisible atom, the non-decomposable element, the indestructibility of matter. When, therefore, as one of the first-fruits of his discovery that positive rays furnish the most delicate method of chemical analysis, Sir J. J. Thomson has obtained from the most diverse solids a new gas, X_3; and by a different procedure, Prof. Collie with Mr. Patterson have discovered that hydrogen, under the influence of electric discharges at low pressure, becomes replaced by neon, helium, and a third gas which is possibly identical with X_3,[2] it is not surprising that we should hear much about it in the newspapers, just as was the case when the disintegration of radium was in process of being established. Further investigation may fail to substantiate some of the views which have been expressed about this unexplained disappearance of hydrogen; the origin of the neon and helium which make their appearance in the tube as the experiments proceed; the source of the gas X_3. Fortunately, X_3, unlike neon and helium, has some chemical properties—it disappears, for example, when violently exploded with a mixture of oxygen and hydrogen[3]—but we do not yet know whether it is a new element with an atomic weight of about 3, or a compound of hydrogen with an element yet to be discovered. This much at least seems certain: it is not the gas which, according to Mendeleef, should precede fluorine in the halogen series, but whether its discovery, like that of argon, will necessitate a revision of the periodic table of the elements we cannot know until the mystery which at present surrounds it has been dispelled.

It was in 1886, at the last meeting of this association in Birmingham, that Sir William Crookes—whose continued activities are a source of pride and gratification to his brother chemists—gave that famous address in which, clothing his ideas in language which has something of the magic of word-painting, he traced the evolution of the elements, as we know them, from the hypothetical protyle or Urstoff. The common origin of all elementary substances is now an accepted theory, although the question whether the idea underlying the term "transmutation" is verifiable under available conditions is answered differently according to the view we take of the disintegration of radium and kindred phenomena. But no one could have imagined that before another Birmingham meeting, the periodic table to which Sir William Crooks devoted much attention would have been enriched not only by a series of

[1] These schools in 1881 became the Normal School of Science, and in 1900 the Royal College of Science, now incorporated in the Imperial College of Science and Technology.

[2] J. N. Collie and H. S. Patterson, Trans. Chem. Soc., 1913, ciii., 419; Proc. Chem. Soc., 1913, xxix, 217.

[3] Sir J. J. Thomson, Proc. Roy. Soc., 1913, lxxxixA. 20.

elements devoid of chemical properties, but by a second series, known only in minute quantities, and displaying those extraordinary properties of radioactivity which have revolutionised our ideas in more than one direction.

It is not necessary for me to chronicle even the more striking achievements in chemistry since 1886; a few examples will show how great the progress has been. It is on record that Arrhenius was present at that meeting, but his advocacy of that theory of solutions with which his name will always be associated came a little later; phenylhydrazine, which was to play so important a part in Emil Fischer's investigation of the sugars, had been discovered by him only two years previously; the Grignard reagent, which in other directions has played a no less important part in synthetical organic chemistry, did not become available until some fourteen years later. Theories then emerging, such as that of geometrical isomerism, have either been discarded or modified by the discovery of new facts, and who shall say that the ionic theory of dissociation stands where it did, now that ions in solution have incurred the suspicion of associating with the solvent, and to that extent have come into line with molecules, for the orthodox behaviour of which Prof. Armstrong himself would no doubt be prepared to vouch.

Residual Valency.

Among the many doctrines which have suffered under the stress of long-sustained investigation, that of valency is a prominent example. Valency is that property by which an atom attracts to itself other atoms or radicals, and its numerical value is deduced from the structural formulæ of compounds in which that atom occurs. Claus seems to have been the first to recognise that this attraction between two atoms is not a constant, but depends on the nature of the other atoms or radicals in the molecule,[4] and it is of interest to note in connection with what follows that he used methane and its chloro-derivatives to illustrate his point of view. Valency may vary, therefore, from compound to compound; it is known to alter under the influence of change in temperature, as, for example, when carbon dioxide or phosphorus pentachloride undergoes thermal dissociation. But Claus's view did not meet with ready acceptance; hence at the Birmingham meeting few chemists, if any, would have questioned the quadrivalency of carbon, despite the difficulty caused by the existence of carbon monoxide. Now, carbon is believed to be bivalent in the carbamines, fulminic acid and other compounds, as well as in carbon monoxide, and its tervalency is coming to be accepted in the light of the latest investigations on triphenylmethyl and its congeners. What is true of carbon is equally true of all other elements, except argon and its companions. Hence the doctrine of constant valency for which Kekulé contended, or that of variable valency in which the uncombined units varied by even numbers has necessarily given place to one of less rigid type, although the final form has yet to be determined.

For the purpose of this address it will be sufficient to refer only to one of these later theories: that in which Werner, as the outcome of his exhaustive study of inorganic molecular compounds, and especially of the ammines, supposes that an atom may have both principal and auxiliary or residual valency.[5] There are difficulties in its application to certain problems of organic chemistry—for example, the structure of the benzene molecule—but the conspicuous success which has attended Werner's investigation of the complicated isomerism of the cobalt and chromium ammines is evidence of its value as a guide in stimulating research in the most unpromising directions.[6] Werner's view that valency is an attractive force acting from the centre of the atom, being of equal value at all points on the surface and independent of units of affinity, has the merit of meeting the objection long urged to the idea that affinity has fixed direction in space, but otherwise leaves untouched Van't Hoff's brilliant conception of asymmetry which plays so great a part in the chemistry of to-day.

What light does this conception of residual valency, dating back to 1885, if not earlier,[7] and now embodied in many theories besides Werner's, throw on some of the problems with which the organic chemist is faced? Much every way. The question of the distribution of valency in the molecules of carbon compounds is discussed probably more than any other; it arises in connection with the structure of unsaturated compounds, the properties of fluorescence or colour which many of them exhibit, and the relation between chemical constitution and physical properties, to the elucidation of which an increasing amount of research is being directed. The double linkings in our formulæ no longer represent two units of valency in terms of hydrogen, nor are they now used to indicate polarity of the central atom or distribution of the valency in space; Werner's conception of valency accounts, as the phrase goes, for the concentration of re-activity at that part of the molecule where unsaturation exists, and it is of service when different degrees of unsaturatedness are displayed by compounds which, on the older view, would be expected to show similarity in chemical behaviour.[8] With your permission I propose briefly to review our knowledge of that type of chemical change known as substitution from the point of view of residual valency.

Substitution in the Paraffin Series.

So far back as 1839 the fact was discovered that replacement of hydrogen by chlorine in the acetic acid molecule does not lead to any essential modification in the properties of the acid. It is not a little remarkable, therefore, that although much of the progress in organic chemistry has been achieved by substitutions of the most diverse types, we are still unable to say that agreement has been reached with regard to the nature of the processes by which this replacement of one radical by another in a molecule is brought about. Never has attention been concentrated more closely than now on the study of what, for want of a better phrase, is termed the "mechanism of chemical reactions"—the processes which are covered and hidden by the sign of equality used, inaptly, in chemical equations—but the integrating mind, to the need for which Professor Frankland alluded on a recent occasion,[9] has not yet been evolved to reconcile the uncertain or contradictory answers vouchsafed to much patient experimenting. Organic

4 A. Claus, *Ber.*, 1881, xiv, 435. It may be noted that Claus concludes his paper with the statement, ". . . die Annahme von Valenzen, als in den mehrwerthigen Atomen präexistirender ihrer Wirkungsgrösse nach bestimmter Anziehungseinheiten eine ebenso unbegründete, wie unnatürliche Hypothese ist."

5 A. Werner, "Neuere Anschauungen auf dem Gebiete der anorganischen Chemie" (Friedr. Vieweg u. Sohn, Braunschweig, 1908): English edition. "New Ideas on Inorganic Chemistry." E. P. Hedley. (Longmans, 1911.)

6 A. Werner, *Ber.*, 1911, xliv, 2445, 3231.

7 S. U. Pickering, Proc. Chem. Soc., 1885, i, 122; H. E. Armstrong, Proc. Roy. Soc., 1886, xl, 285.

8 As an example of the unsatisfactory character of the doubly-linked formula to which the older meaning was attached, the following may be quoted: *unsym.*-Diphenyldichloroethylene, like ethylene, combines molecularly with bromine, but tetraphenylethylene does not:

$$\begin{array}{ccc} CH_2 & C(C_6H_5)_2 & C(C_6H_5)_2 \\ \| & \| & \| \\ CH_2 & C\,Cl_2 & C(C_6H_5)_2 \end{array}$$

yet a similar structure has been assigned to each (Biltz, *Annalen*, 1897 ccxcvi, 219).

9 P. F. Frankland, Proc. Chem. Soc., 1913, xxix, 101.

chemistry is not singular in this respect: as much might be said about controversies not yet settled which concern themselves with such every-day phenomena as the chemistry of the candle-flame or of the rusting of iron.

It is a commonplace that Kekulé, to whom theoretical chemistry owes so many fruitful suggestions, was of the opinion that substitution is not a process in which what may be called a direct exchange of radicals occurs, but is preceded by the temporary union of the molecules of carbon compound and addendum, followed by disruption into two new molecules, the substituted carbon compound being one of them. It is clear, then, from the point of view of Kekulé's hypothesis, that some degree of unsaturation is to be looked for in all carbon compounds and in all addenda. Hence, the paraffin hydrocarbons which furnish derivatives only by substitution, and, under the older, more rigid view of valency propounded by Kekulé himself, are typically saturated compounds, supply the exceptions to prove the general validity of the hypothesis that addition precedes substitution.

Before examining the case of these hydrocarbons, however, some advantage may be gained if the behaviour of other groups of compounds be examined in the light of the idea underlying Kekulé's view. By reference to the literature, it is evident that since the beginning of this century attention has been concentrated on the phenomena of substitution in the important group of carbonyl compounds, particularly the ketones and acids, which in many cases yield halogen substitution derivatives of one type. Thus methyl ethyl ketone when brominated in sunlight yields two bromoketobutanes of the constitution shown in the following formulæ, and propionic acid with bromine and red phosphorus under Volhard's conditions [10] gives α-bromopropionic acid,

$$CH_2Br.CO.CH_2.CH_3 \text{ and } CH_3.CO.CHBr.CH_3 \;^{11}$$
$$CH_3.CHBr.CO.OH$$

the halogen occupying what is termed the α-position with reference to the carbonyl radical. Why is substitution easier in the methyl group when it is present in the ketone or acid than when it occurs in methane, is one question that may be asked. A second will inquire whether the carbonyl group has a directing influence, and, if so, by what means is it exercised.

It has been supposed by Werner that the distribution of valency is disturbed by the introduction of the oxygen atom of the carbonyl group into the molecule of the hydrocarbon; that this oxygen atom absorbs much of the valency of the carbon atom of the carbonyl group, leaving less to bind its neighbour or neighbours, which results in their having free valency, and thereby attaching substituents to themselves. This explanation, if accepted for the bromination of ketones and acids, also for the chlorination of ketones, does not account for the results recorded by Michael and by Montemartini in the case of carboxylic acids. Michael has found that the β-chloro-, not the α-chloro-acid is the chief product (60–65 per cent.) when homologues of acetic acid are chlorinated [12]; and Montemartini states that if the radical CH occur in any part of the carbon chain the exchange of hydrogen for chlorine takes place in that position, however distant it may be from the carbonyl group of the acid. [13]

[10] J. Volhard, *Annalen*, 1887, ccxlii, 141; *Ber.*, 1888, xxi, 1904.
[11] L. Van Raymenant, Bull. Acad. roy. Belg., 1900, 724. For the chloroketobutanes, cf. *idem.*; Kling, Compt. rend. 1905, cxl, 312; Bull. Soc. chim., 1905 [iii], xxxiii, 322.
[12] A. Michael, *Ber.*, 1901, xxxiv, 4035, 4046.
[13] C. Montemartini, Gazz. chim. ital., 1897, xxvii [ii], 368; 1898, xxviii [ii], 290.

$$CH_3.CH_2.CHCl.CH_2.CO.OH$$
(Michael)

$$\begin{matrix} CH_3 \\ CH_3 \end{matrix} \!\!> CCl.CH_2.CH_2.CO.OH$$
(Montemartini)

At present there seems to be no clue to the reason why chlorine and bromine in these reactions behave alike towards ketones and not towards acids.

An alternative explanation of this reaction, which has come to be widely accepted, is based on the remarkable property called desmotropy or dynamic isomerism, which certain of these carbonyl compounds exhibit. A desmotropic compound may exist in two or more forms, and its peculiar isomerism is known to depend on the mobility of a hydrogen atom in the complex $.CH_2.CO.$ whereby an equilibrium is set up of the type:

$$\underset{\text{Ketonic form}}{.CH_2.CO.} \rightleftharpoons \underset{\text{Enolic form}}{.CH{:}C(OH).}$$

Of these two forms, the enolic is the more unsaturated, and presumably the more reactive. [14] Lapworth, making use of this desmotropic relationship, supposes that when the ketone reacts with halogen in dilute aqueous solution three changes occur which, for the case of acetone, may be represented by the following expressions:—

$$CH_3.CO.CH_3 \rightarrow CH_3.C(OH){:}CH_2$$
$$CH_3.C(OH){:}CH_2 + Br_2 \rightarrow CH_3.C(OH)Br.CH_2Br$$
$$CH_3.C(OH)Br.CH_2Br \rightarrow CH_3.CO.CH_2Br + HBr$$

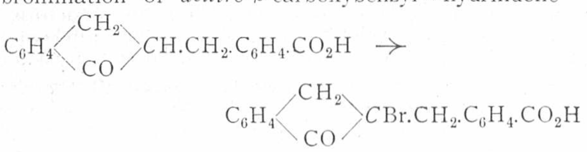
the first being one of slow enolisation, accelerated catalytically by halogen acid, leading to the production of an unsaturated compound, which then by rapid addition of bromine and subsequent elimination of hydrogen bromide conforms with Kekulé's hypothesis. The intermediate compounds, it is true, have not been isolated, but a study of the dynamics of the reaction by Lapworth, and later by Dawson with his collaborators (using iodine instead of bromine), shows that this explanation is in harmony with the data obtained. [15] When the reaction is applied to carboxylic acids under similar conditions, the view that it takes a similar course finds support from an investigation of the dynamics of the bromination of malonic acid in aqueous solution. [16]

Whether evidence drawn from reactions found to take place in aqueous solution is relevant when bromination is effected by heating a carboxylic acid with bromine and red phosphorus may be doubted. Certainly it seems to afford no assistance in accounting for the course of chlorination in the acids examined by Michael and by Montemartini. Nevertheless, Aschan employs the keto-enolic hypothesis [17] to elucidate the results of a recent inquiry into the "mechanism" of the Volhard reaction [18]; and it may be added that racemisation has been found to occur when *laevo*-valeric acid is brominated by Volhard's method [19]—a result which must follow if enolisation

[14] It may be of interest to note that the long controversy respecting the composition of ordinary ethyl acetoacetate $CH_3.CO.CH_2.CO.OEt$, the first of these desmotropic compounds to be discovered, has been brought to an end by the isolation of each desmotropic form at temperatures sufficiently low to inhibit the desmotropic change. From refractometric observations with mixtures of the pure isomerides, Knorr concludes that this ester at the ordinary temperature contains about two per cent. of the enolic form, whereas from bromination experiments with the ester itself, which may possibly be accompanied by a disturbance of the equilibrium, K. H. Meyer infers that the amount may be as much as seven per cent. (L. Knorr, O. Rothe, and H. Averbeck, *Ber.*, 1911, xliv, 1138; K. H. Meyer, *Annalen*, 1911, ccclxxx, 222; K. H. Meyer and P. Kappelmeier *Ber.*, 1911, xliv, 2718.)
[15] A. Lapworth, Trans. Chem. Soc., 1904, lxxxv, 31; H. M. Dawson with May S. Leslie, *ibid.*, 1909, xcv, 1860; with R. Wheatley, *ibid.*, 1910, xcvii, 2048; with F. Powis, *ibid.*, 1912, ci, 1503.
[16] K. H. Meyer, *Ber.*, 1912, xlv, 2867.
[17] O. Aschan, *Ber.*, 1912, xlv, 1913; 1913, xlvi, 2162; K. H. Meyer, *Ber.*, 1912, xlv, 2868.
[18] J. Volhard, *loc. cit.*
[19] O. Schütz and W. Marckwald, *Ber.*, 1896, xxix, 58.

take place, although susceptible of another explanation.

So far as I can form a judgment, no case has been made out for the view that substitution of halogen for hydrogen under Volhard's conditions differs in its "mechanism" from substitution in the paraffins. This opinion finds support in the discovery just announced by Leuchs[20] that, while the chief product of the bromination of *dextro*-β-carboxybenzyl-α-hydrindone



is the racemic compound, no less than 10 per cent. is the *dextro*-bromo-derivative; therefore, the inference is clear that in the formation of the latter compound, if not of both, substitution was effected by a process in which migration of the hydrogen atom did not occur.

Attention may now be directed to the question of "direct substitution," which, in its simplest form, is encountered in the paraffin series. As will be gathered from the following selection from among the various theories propounded to account for the mechanism of substitution, alternative explanations of the intermediate reactions leading up to substitution in these cases involve either elimination of the hydrogen atom before introduction of the halogen, or addition of the halogen in virtue of the supposed residual valency of both molecules, followed by disruption of the complex thus formed into the known products of the change.

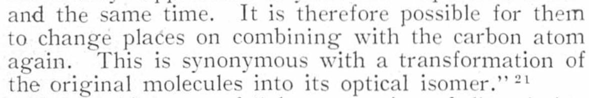
Dealing with these alternatives in the order given, Arrhenius adopts a view of the process of substitution which, including as it does his explanation of optical inversion and racemisation, should perhaps be given in his own words:—

"Every valency linking can be broken; this is true in all cases, since it is a necessary condition for every chemical reaction. An atom or an atomic complex is thereby removed from the molecule, and its place taken by another atom or atomic complex. One must therefore assume, as was first pointed out by Williamson, that the atoms or complexes separate themselves from the molecule from time to time, even when they do not react with other molecules. Consider now a molecule in which four different atoms, A, B, C, and D, are bound to one carbon atom. The atoms A and B, which may possess equal charges, *e.g.* positive, are therefore separated at times from the molecule, and it may happen that they are both separated at one and the same time. It is therefore possible for them to change places on combining with the carbon atom again. This is synonymous with a transformation of the original molecules into its optical isomer."[21]

Nef, making use of "the conception of dissociation in its broadest sense," is of opinion that the decomposition of ethane into hydrogen and ethylene at 800° "proves that an extremely small per cent. of [its] molecules must exist at ordinary temperature in an active or dissociated condition,

$$CH_3.CH_3 \rightarrow CH_3.CH_2 + H -$$ "[22]

consequently, when "chlorine reacts with ethane to give the monochloro-substitution product, we have this reagent in the *active molecular* condition simply uniting by addition with the dissociated ethane particles,



[20] H. Leuchs, *Ber.*, 1913, xlvi, 2435.

[21] S. Arrhenius, "Theories of Chemistry," edited by T. Slater Price (Longmans, 1907), p. 76.

[22] J. U. Nef, "The Fundamental Conceptions underlying the Chemistry of the Carbon Atom," J. Amer. Chem. Soc., 1904, xxvi, 1566.

Finally, he draws the conclusion that "excluding reactions called ionic, a chemical reaction between two substances always first takes place by their union to form an additive compound."

Michael,[23] in many published papers, has emphasised the view that in the substitution of halogen for hydrogen in a saturated hydrocarbon or saturated acid the principal factors to be taken into account are the mutual chemical attraction of the two elements, on one hand, and that of the halogen and carbon, on the other. By applying his "positive-negative" hypothesis to the directing influence of "relatively-positive" methyl, and "relatively-negative" carboxyl, he draws conclusions about the degree of firmness or looseness with which particular hydrogen atoms are bound to carbon in the molecule, and is thereby able to forecast with some success the position or positions in which replacement of hydrogen by halogen will occur. Flürscheim, in the discussion of the relation between the strength of acids and bases, and the quantitative distribution of affinity in the molecule, also makes use of the idea that the relative degree of firmness or looseness with which a hydrogen atom is held depends on the nature of the other atoms or radicals associated with the same carbon atom.[24] The hydrogen atoms therefore are not to be regarded as retained in the molecule with the same degree of firmness; in other words, valency is not a constant to be measured in units.

It will be gathered therefore that Arrhenius and Nef, from different points of view, support the idea that separation of hydrogen from the hydrocarbon precedes entry of the substituent into the molecule; Michael and Flürscheim are concerned chiefly with the distribution of valency in the molecule, which determines whether a particular hydrogen atom shall be displaced by hydrogen or not; Kekulé's hypothesis requires addition to precede substitution. Is there any experimental evidence to indicate where the balance of probability lies? I think it can be argued that the phenomena of substitution observed with optically active substances do not lend support to the views of Arrhenius or of Nef, which imply actual or virtual dissociation, but that they point to the intermediate formation of an additive product, which undergoes scission as Kekulé supposed. Such an additive product can be formed only if residual valencies be present in both carbon compound and addendum.

The argument runs thus: Unless valency has fixed direction in space, a conception now abandoned if modern theories of valency be accepted, the conclusion seems to be inevitable that dissociation of the optically active compound:—

$$CWXYZ \text{ into } CWXY + Z,$$

must lead to racemisation, the radicals W, X, Y, distributing themselves in two-dimensional space, thus destroying the asymmetry; whence it follows that introduction of the substituent, V, into the molecule in place of Z can give rise only to an optically inactive product. Now, it is a well-established fact that a radical attached directly to the asymmetric carbon atom may be replaced by another without racemisation following.[25] Therefore, preliminary dissociation being excluded, Kekulé's additive hypothesis remains. But the prolonged study of that remarkable reaction known as the "Walden inversion" by Emil Fischer, McKenzie, and other investigators, has led to results

[23] A. Michael, *Ber.*, 1901, xxxiv, 4028, covering reference to earlier papers.

[24] B. Flürscheim, Trans. Chem. Soc., 1909, xcv, 721.

[25] P. Walden, *Ber.*, 1895, xxviii, 1297; W. Tilden and B. M. C. Marshall, Trans. Chem. Soc., 1895, lxvii, 494.

which, if the views formed independently by Fischer,[26] Werner,[27] and Pfeiffer[28] may be accepted, are inexplicable unless a preliminary addition, effected as it is supposed by means of residual valencies, precedes this replacement of the eliminated radical by the substituent.

The Walden inversion may be illustrated by a brief statement of some of the facts discovered in connection with the conversion of optically active chlorosuccinic acid into malic acid

$$R.CH(OH).CO_2H \longrightarrow R.CHCl.CO_2H \longrightarrow R.CH(OH).CO_2H.$$

Walden found that *laevo*-chlorosuccinic acid, obtained from *dextro*-malic acid, furnished either *dextro*- or *laevo*-malic acid, according to the reagent used to effect of the replacement of the Cl by the OH radical.

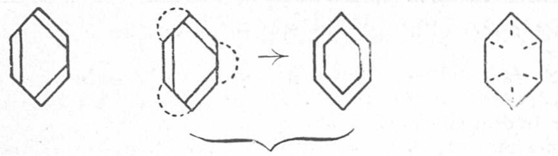
$$l\text{-chlorosuccinic acid} \begin{cases} (+ Ag_2O) \rightarrow l\text{-malic acid} \\ (+ KOH) \rightarrow d\text{-malic acid.} \end{cases}$$

And as the corresponding inversion was found to occur with *dextro*-chlorosuccinic acid under similar conditions, a complete cycle of changes can be brought about.[29] That preservation of optical activity, and not racemisation, should accompany the replacement of a radical, attached to the asymmetric carbon atom, by another is a fact of much theoretical interest, as has already been indicated; that a change in the sign of rotation should occur when an exchange of the same radicals is achieved by one reagent and not by another is a mystery, that deepens rather than diminishes with each addition to the list of inversions, already long, in which it has been observed.[30] In all probability the discovery of the Walden inversion, as Prof. Frankland has said, "may mark an epoch in our views with regard to the mechanism of the process of substitution in general."[31]

The Structure of the Benzene Molecule.

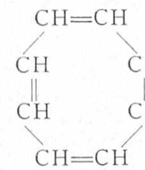
The abandonment of the theory of the fixed valency unit in favour of the view that the carbon atom has both principal and residual valencies has raised afresh that perennial topic of controversy—the structure of the benezene molecule. Probably few will contest the statement that for practical purposes only three formulæ have emerged from the long discussion of the problem, viz. Kekulé's oscillation formula with fixed valency units, for which much physical evidence has been pleaded: Thiele's formula, in which his theory of "conjugated double linkings" is applied to the Kekulé formula, with the consequence that the three double linkings disappear owing to self- neutralisation of the partial valencies, the benzene molecule thus containing six inactive double linkings;[32] and Armstrong's "centric" formula, in which by its residual valency "each individual carbon atom exercises an influence upon each and every other carbon atom."[33] The dotted lines indicate the residual valencies.

[26] E. Fischer, *Annalen*, 1911, ccclxxxi, 123.
[27] A. Werner, *Ber.*, 1911, xliv, 873.
[28] P. Pfeiffer, *Annalen*, 1911, ccclxxxiii, 123.
[29] P. Walden, *Ber.*, 1896, xxix, 133; 1897, xxx, 3146; 1890, xxxii, 1833, 1855.
[30] Without the aid of a model it is not possible to show that the production of the *dextro*- or *lævo* acid may be accounted for by the hypothesis that an intermediate additive compound is formed, which undergoes scission in one or other of two ways. Diagrams of models will be found in Fischer's paper (*loc. cit.* cf. "Annual Reports on the Progress of Chemistry" (Gurney and Jackson, 1911, viii, 67), and to illustrate Werner's hypothesis, which is more explicit than Fischer's, in a paper by W. E. Garner (Proc. Chem. Soc., 1913, xxix, 200)
[31] P. F. Frankland, "The Walden Inversion," Presidential Address to the Chemical Society (Trans. Chem. Soc., 1913, ciii, 713).
[32] J. Theile, *Annalen*, 1899, cccvi, 126.
[33] H. E. Armstrong, Trans. Chem. Soc., 1897, li, 264 (footnote),



Kekulé. Thiele. Armstrong.

The discovery of *cyclo*octatetraene has brought a new interest into the discussion,[34] for the structural formula assigned to this hydrocarbon shows alternate single and double linkings as in Kekulé's symbol, and the optical behaviour (refractivity) corresponds with that of benzene.



But its chemical properties are entirely different from those of benzene; it forms compounds not by substitution but by addition, and it has the reactivities of a highly unsaturated compound. If these experimental results be accepted, then—as Willstätter shows—the peculiar properties of benzene are not to be explained by Kekulé's or Thiele's formula, and the verdict is given in favour of the "centric" symbol—that earliest embodiment of the conception of residual valency, which Armstrong later turned to such good account in the quinonoid theory of colour identified with his name.

The reference to the optical behaviour of *cyclo*-octatetraene may perhaps suggest the inquiry: Do not the physical properties of the carbon compounds throw light on the questions that have been raised? A little consideration will show that, on the contrary, the answer must be: It is only by chemical evidence that physical data can be interpreted or corroborated, and in the absence of such evidence the "additive" results which accrue from physical observations have no bearing on questions involving the determination of structure or the structural transformations which accompany a chemical change. For example, the anomalous results obtained by Brühl and by Sir William Perkin[35] in the investigation of the refractivity and the magnetic rotation of certain unsaturated compounds, remained without explanation until Thiele in 1899, by his hypothesis of partial valency, accounted for the comparative inactivity of the central pair of carbon atoms in compounds of this type—compounds which are characterised by containing alternate single and double linkings in their formulæ:—

$$.CH:\dot{C}H.CH:CH. \rightarrow .CHBr.CH:CH.CHBr.$$

This conception of Thiele's has both focussed attention on the distribution of valency within the molecule, contributing largely to the wide acceptance of theories of valency such as Werner's, and given to the study of physical properties—especially those "constitutive" properties of refraction, dispersion, and magentic rotation—an impetus which has by no means spent its force. Further, the occurrence of this anomaly, "exaltation" as it is called, is now relied on as evidence of the presence of this particular distribution of valency, with results which in Auwers's

[34] R. Willstätter and E. Waser, *Ber.*, 1911, xliv, 3423.
[35] *Cf.* J. W. Brühl, *Ber.*, 1907, xl, 878; Sir W. H. Perkin, Trans. Chem. Soc., 1907, xci, 806, for references to earlier papers.

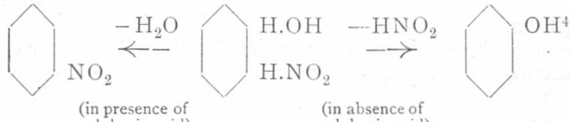
hands have furnished important clues to the structural formulæ of terpenes and other compounds.

As additive properties become constitutive, so the value of a knowledge of the physical properties of a substance will tend to increase, but there is little ground for hope that the problem of the constitution of benzene will be solved from the physical side. The controversy which has arisen between Hantzsch and Auwers regarding the physical properties of *cyclo*-tatetraene in relation to its chemical structure is a case in point;[36] the absence of optical exaltation in this hydrocarbon is wholly unexpected, but, on the other hand, the type of compound is entirely new. With benzene also the distribution of valency within the molecule differs from that in any known compound; our knowledge of it, admittedly far from complete, has been gained from the chemical side, and is summarised in the various structural formulæ; but the limitations of the physical method of attack can be traced from Thomsen's endeavour to determine its structure from thermochemical data[37] to the more recent invention of isorropesis. And, despite the evidence obtained from refractivities, we may not unreasonably demur to the suggestion that derivatives of benzene, which by their behaviour towards substituting agents show themselves to be wide apart in chemical properties, such as nitrobenzene and aniline on one hand or chlorobenzene and phenol on the other, should respectively be classified together.[38]. Undoubtedly, most useful information is obtained from a comparison of the physical properties of two related substances, the exact constitution of one of which is uncertain, but that of the other known. Therefore, bearing in mind the great development that has taken place recently in the correlation of physical properties with chemical constitution by methods based on refraction and absorption, every chemist will welcome the entry of Dr. Lowry into that field of research on the relation between magnetic rotation and structure, which for all time will be associated with Sir William Perkin's name.

Substitution in the Benzene Series.

Turning now to a discussion of the problem of substitution in cyclic compounds, one important factor must not be overlooked; the even distribution of the residual affinity of the benzene molecule is disturbed by the introduction of a substituent. The study of substitution in benzene derivatives indicates that, as a consequence of this disturbance, a directing influence comes into play which, when the substituent is changed, may vary in the effect it exercises on the course of substitution.

Arising probably from this even distribution of valency, it is characteristic of benzene to furnish additive compounds in which six atoms of hydrogen or a halogen, but not two or four, become attached symmetrically to the molecule; substitution, however, occurs when a catalyser is present, such as the aluminium-mercury couple for halogenation, or sulphuric acid for nitration or sulphonation, leading initially to the production of mono-substituted derivatives. Whether the catalyser by association with the benzene molecule[39] limits this additive capacity, or whether its function is to promote the elimination of the halogen acid or water respectively,[40] is still a subject of discussion, but in the absence of a reaction of additive type it is not easy to account for facts such as the production of a certain amount of trinitrophenol when benzene is nitrated in the absence of sulphuric acid.



(in presence of sulphuric acid) (in absence of sulphuric acid)

The much-debated questions still remain: Why and by what mechanism, when a second or third substituent is introduced into the molecule, is the orientation of the isomeric products determined by the radical or radicals already present? For disubstitution, the *ortho-para-* and the *meta*-laws have been deduced, and the radicals which respectively promote mainly *ortho-para*-substitution on one hand, and *meta*-substitution on the other, have been catalogued.[41] But these laws take account only of the orientation of the chief product or products, whereas all three derivatives, *ortho, meta,* and *para,* have been detected in most of the reactions studied, and their relative proportion in many cases is known to depend on the conditions, being affected by such influences as variation in temperature or in the medium employed.[42] Nitration of acetanilide, for example, furnishes a mixture of *ortho-* and *para*-nitracetanilide, but of aniline in the presence of much sulphuric acid yields chiefly *meta*-nitraniline.[43] And, to illustrate the inadequacy of the *meta*-law, the fact that sulphonation of benzenesulphonic acid with concentrated sulphuric acid at 230°–240° furnishes an equilibrium mixture of the *meta-* and *para*-disulphonic acids in the proportion of 2 : 1 may be quoted.[44]

In the exploration of this field many workers have participated, but the results, recorded almost as often in patent specifications as in journals, are seldom quantitative, so great is the difficulty at times in isolating the minor product or products of the change. Recently, however, by a most ingenious use of melting-point curves and density determinations, Holleman and his collaborators have carried out an exhaustive series of substitutions with small quantities of material and under known conditions;[45] yet after a survey of the whole field the conclusions reached are:—

(1) That uncertainty cannot be removed until some basis exists for different reactions to be carried out under comparable conditions.[46]

(2) That even if the relative amounts of the isomerides formed when a radical C is introduced into each of the mono-substitution derivatives C_6H_5.A and C_6H_5.B be known, it is not possible to calculate the proportion in which the isomerides C_6H_3.ABC will be produced when the radical C is substituted in the compound C_6H_4.AB.

Although the validity of the *ortho-para* and of the *meta*-laws may be impeached, they serve as a first approximation, and many theories have been propounded to account for them. Armstrong has suggested that in *ortho-para*-substitution the additive compound is formed by association of the addendum with the carbon atom carrying the radical already substi-

36 A. Hantzsch, *Ber.*, 1912, xlv, 563; K. Auwers, *ibid.*, 971.

37 *Cf.* H. E. Armstrong, Phil. Mag., 1887 [v.] xxiii, 73; J. W. Brühl, J. pract. Chem., 1887 [ii], xxxv, 181, 209.

38 *Cf.* J. W. Brühl, Zeit. Physikal. Chem., 1894, xvi, 220; Smiles, "Relations between Chemical Constitution and Physical Properties" (Longmans, 1910), p. 299.

39 B. N. Menschutkin, Abstr. Chem. Soc., 1912, cii, i, 98–100.

40 *Cf.* H. E. Armstrong, Trans. Chem. Soc., 1887, li, 263.

41 The phenol by nitration forming the trinitro- derivative (picric acid), Armstrong and Rossiter, also Groves, Proc. Chem. Soc., 1891, vii, 89.

42 *Cf.* Noelting, *Ber.*, 1876, ix, 1797; Armstrong, Trans. Chem. Soc., 1887, li, 258; Crum Brown and Gibson, *ibid.*, 1892, lxi, 367.

43 Hübner, *Annalen*, 1881, ccviii, 299.

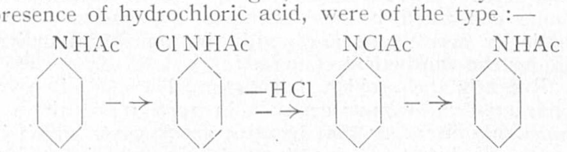
44 J. J. Polak, *Rec. trav. chim.*, 1910, [ii.] xiv, 416; R. Behrend and M. Mertelsmann, *Annalen*, 1911, ccclxxviii, 352.

45 A. F. Holleman, "Die direkte Einführung von Substituenten in den Benzolkern" (Leipzig, Viet and Co., 1910), p. 215.

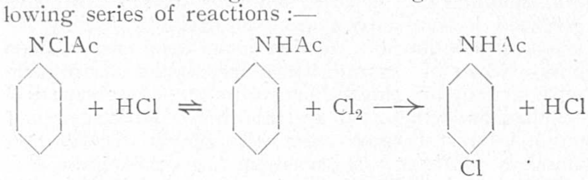
46 For example, nitration is effected chiefly at low temperatures, but sulphonation of mono- substituted benzenes at temperatures higher than the ordinary, which if employed in nitration would lead to mixed products.

tuted in the molecule,[47] whereas in *meta*-substitution it arises by union of the addendum with this radical,[48] transformation to the respective disubstitution derivatives being effected possibly in step-by-step progression, as conjectured by Lapworth.[49] Holleman, who also adopts the additive hypothesis, is of the opinion that the radical already present in the molecule may promote or retard the association of the addendum with the pair of carbon atoms, to one of which it is itself attached. By the operation of the first of the alternatives an *ortho*- and by conjugation a para-derivative will arise; from the second a *meta*-derivative will result, when scission of the additive compound ensues. Holleman's is the only hypothesis which has been submitted to the test of quantitative investigation, and although, as already mentioned, the results do not suggest that finality has been reached, it marks an advance in the study of this obscure problem.[50]

No discussion of substitution in the benzene series would be adequate without reference to the remarkable behaviour of amines and phenols. Unlike other mono-substitution derivatives, which do not differ markedly from benzene in reactivity, these furnish mono-, di-, and tri-derivatives very readily. With aniline or acetanilide, substitution occurs first of all in the side chain, being followed under appropriate conditions by removal of the substituent from the amino-group and entry into positions relatively *ortho-*, *para-*, or both *ortho-* and *para-* to it. The earliest of these changes to be studied was the transformation of methylaniline into *para*-toluidine; many of them have been discovered by Chattaway and his collaborators, and until a critical study of the chlorination of acetanilide was undertaken by Orton and Jones,[51] it was held that the changes, which occur only in the presence of hydrochloric acid, were of the type :—



From the dynamics of the reaction, it is now known that intra-molecular transformation from the side chain to the ring does not occur, the agent promoting the substitution being chlorine arising from the following series of reactions :—



As bromination has been shown to follow the same course, it is evident that no secure foundation now exists for the view, formerly widely held, that the reactivity of amines is intimately connected with the variable valency of nitrogen leading to initial substitution in the side chain.

[47] Kinetic studies of the chlorination and bromination of toluene, $C_6H_5{\cdot}CH_3$, however, gave no indication of the production of an intermediate additive compound of the hydrocarbon and addendum (*cf.* Holleman, Polak, van der Laan, and Euwes, *Rec. trav. chim.*, 1908, xxvii, 435; Bruner and Dluska, Bull. Acad. Sci., Cracow, 1907, 693; Bancroft, J. Physical Chem., 1908, xii, 417; Cohen, Dawson, Blockey, and Woodmansey, Trans. Chem. Soc., 1910, xcvii, 1623.

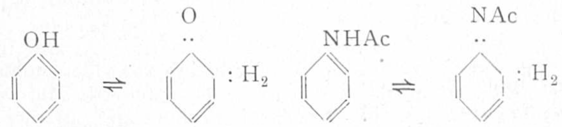
[48] H. E. Armstrong, Trans. Chem. Soc., 1887, li, 258.

[49] A. Lapworth, Trans. Chem. Soc., 1898, lxxiii, 454; 1901. lxxix, 1265.

[50] It should be mentioned that other views, based on the loosening or strengthening of the affinity of the hydrogen atoms situated in *ortho- para-* or in *meta-* positions, brought about by the disturbing influence of the radical already present in the molecule on the valency of the carbon atom to which it is attached, and therefore on that of the other five carbon atoms, have been advanced by Flürscheim (J. prakt. Chem., 1902 [ii], lxvi, 321), Tschitschibabin (*ibid.*, 1912 [ii], lxxxvi, 397), and others.

[51] K. J. P. Orton and W. J. Jones, British Association Report, 1910, p. 96; Trans. Chem. Soc., 1909, xcv, 1456.

Even were this view, now discredited, still applicable to the amines, it could not be extended with the same certainty to the phenols. Hence, in explanation of the rigid adherence to the *ortho-para*-law observed among the mono-substitution derivatives of these two groups of compounds, it is noteworthy that Thiele,[52] for the phenols, suggests that the reactivity may be due to these substances being stable enolic forms of ketodihydrobenzenes, and that Orton,[53] for the amines, conjectures that it may arise from the formation of dynamic isomerides of quinonoid structure :—



How far these suggestions may open up a new field of inquiry into the "mechanism" of substitution remains to be seen; it is at least interesting that their extension to the naphthalene series shows that not only does the reactivity of the naphthols and of α-naphthylamine recall that of phenol and aniline, but the orientation of their mono-substitution derivatives[54] in almost every case is the same as that of one or other of the six naphthaquinones, the existence of which has been predicted by Willstätter.[55]

Symmetric and Asymmetric Syntheses.

It must not be supposed that the "mechanism" of substitution can be explained by reference only to the examples of this type of reaction which have been mentioned, or that the summary attempted in the restricted field of the replacement of hydrogen by halogen is a complete picture of all the different views advanced to account for this chemical change. Rather, the effort has been made to indicate in broad outline the difficulties that beset any exploration of that debatable region which lies between the two sides of a chemical equation. But, as the wonderful story of carbon chemistry shows, the failure to comprehend the processes operative in substitution does not impede rapid progress in other directions. The study of the mobility of radicals, desmotropy being only one of many examples of this phenomenon, continues to present fresh problems, of which that raised by Thorpe[56] in connection with the mobile hydrogen atom of glutaconic and aconitic acids may be mentioned, as it revives a question of old standing: Do free units of valency exist in carbon compounds? The syntheses of caffeine and certain alkaloids, of sugars and peptone-like polypeptides, of natural terpenes and camphor, of indigo and rubber, are well-known achievements, while natural processes, in which enzyme action plays a part, are yielding their closely guarded secrets to the persistent inquiry of Armstrong and his collaborators, who are probing the relationship between enzyme and substrate which Emil Fischer pictured as that of lock and key. Further, there is that large field of work which includes not only the Walden inversion but new problems of asymmetry, with which the names of Frankland, Pope, Werner, and others are associated; while Barlow and Pope's conception of the relation of valency to atomic volume, by correlating crystalline structure with the composition, constitution, and configuration of carbon compounds, has given a new interest to the study of crystallography.

Nor is progress less rapid in that other important branch of chemistry—the unravelling of the structure

[52] J. Thiele, *Annalen*, 1899, cccvi, 129.

[53] British Association Report, 1910, p. 96.

[54] *Cf.* W. P. Wynne, art. "Naphthalene," Thorpe's "Dictionary of Applied Chemistry," second edition, vol. 3 (Longmans, 1912).

[55] R. Willstätter and J. Parnas, *Ber.*, 1907, xl, 1406.

[56] N. Bland and J. F. Thorpe, Trans. Chem. Soc., 1912, ci, 871, 1490.

of natural products. The constitution of rubber is approximately known; most of the alkaloids have been explored with a greater or less degree of completeness; and now the study of starch,[57] chlorophyll, and hæmatin (the non-proteid constituent of hæmoglobin)[58] has been taken up afresh during the last three years, with results which, in the case of the two latter, eclipse in importance and interest all that was previously known. In whatever direction we may look, there is the same evidence that we can take to pieces the most complicated structure which nature has devised, and by the aid of valency conceptions can fit the pieces into a formula which is an epitome of the chemical activities of the molecule. Again, in many cases the resources of our laboratories enable us to build up the structure thus displayed, and to establish the identity of nature's product and our own. Nevertheless, the fact remains that all these syntheses leave untouched and unexplained the profound difference between the conditions we find necessary to achieve our purpose and those by which the plant or animal carries on its work in presence of water and at a temperature differing only slightly from the normal. It is, of course, a well-known fact that an enzyme under the appropriate conditions can bring about the same chemical transformation of a substrate as is effected by the living cell from which it can be separated; but our knowledge of these complex, ill-defined, nitrogenous organic compounds is relatively very meagre; they are difficult to purify, and their composition—apart from any question of structure—is largely unknown. Yet because Wöhler chanced to discover that urea can be produced synthetically from an inorganic source the conclusion is not infrequently drawn that all chemical changes in living substance are brought about by ordinary chemical forces.[59] Probably everyone present will concur in that view, but the assent, if given, can scarcely arise from a consideration of the facts, of which there is no great store. Where so little is known accurately, chemistry is not on very safe ground if she infer the rest. What common basis of comparison exists between Wöhler's process and the metabolic changes by which urea is produced in the living body? What evidence have we that because an enzyme and an inorganic agent under different conditions give rise to the same end product, the driving force is the same, although the lines along which it is exercised are very different? I think it is not the least of the many services which Prof. Meldola has rendered to chemistry, that he has given us this warning: "If we have gone so far beyond nature as to make it appear unimportant whether an organic compound is producible by vital chemistry or not, we are running the risk of blockading whole regions of undiscovered modes of chemical action by falling into the belief that known laboratory methods are the equivalents of unknown vital methods."[60]

I turn now to a no less interesting question than that involved in enzyme reactions, namely the wide distribution in plants and animals of single asymmetric substances which if synthesised in the laboratory would be produced as inactive mixtures of both asymmetric forms. It has been argued that the occurrence of racemic compounds in nature, although infrequent, is a proof that in the organism, as *in vitro*, they are in all cases the initial products from which, when separated into antipodes, one of the asymmetric compounds is utilised in the life processes and the other left. But whether this be the case, or whether only the one asymmetric form result from the synthesis, Pasteur firmly held the view that the production of single asymmetric compounds or their isolation from the inactive mixture of the two forms is the prerogative of life. Three methods were devised by Pasteur to effect this isolation, and in only one of them are living organisms—yeasts or moulds—employed; but Prof. Japp, in his address to this Section at Bristol in 1898, emphasised the fact, hitherto overlooked, that in the two others, nevertheless, "a guiding power [is exercised by the operator] which is akin in its results to that of the living organism, and is entirely beyond the reach of the symmetric forces of inorganic nature." Hence, to quote again from his address, "Only the living organism with its asymmetric tissues, or the asymmetric products of the living organism, or the living intelligence—with its conception of asymmetry, can [bring about the isolation of the single asymmetric compound.] Only asymmetry can beget asymmetry." After an exhaustive review of the subject, Japp came to the conclusion that the failure to synthesise single asymmetric compounds without the intervention, either direct or indirect, of life is due to a permanent disability, and although—as was to be expected—this conclusion was challenged,[61] the only "asymmetric syntheses" effected since that time have been operations controlled by the chemical association of an optically active substance with the compound undergoing the synthetical change.[62]

Recently the problem has assumed a more hopeful character. Ostromisslensky[63] in 1908 made the remarkable discovery that inactive asparagine, which is not racemic but a mixture of the *dextro*- and *laevo*-forms in molecular proportion, gave a separation of one or other isomeride when its saturated solution was inoculated by a crystal of glycine—a substance devoid of asymmetry. Now Erlenmeyer claims to have achieved a true asymmetric synthesis by boiling an aqueous solution of inactive asparagine for sixteen hours, when by crystallisation part of the *dextro*-form separated in an almost pure state.[64] The theoretical conclusions which led to this investigation are of much interest because they raise afresh the question whether without displacement of the individual radicals, and apart from antipodes, more than one compound can exist, in the molecule of which two carbon atoms are united by a single linking.[65] As an illustration, reference may be made to the malic-acid series, in which three optically active compounds are known, the *dextro*-acid, the *laevo*-acid, and Aberson's acid.[66] In the *laevo*-series the three isomerides obtainable by rotation of one of the carbon atoms with its attached radicals relatively to the other would be

57 H. Pringsheim and H. Langhans, *Ber.* 1912, xlv, 2533.

58 For summaries of Willstätter's and Marchlewski's researches on chlorophyll. and of Piloty's on hæmatin, *cf.* "Annual Reports on the Progress of Chemistry (Gurney and Jackson) 1911, viii, 144–152; 1912, ix, 165–172.

59 "Quite similar changes can be produced outside the body (*in vitro*) by the employment of methods of a purely physical and chemical nature. It is true that we are not yet familiar with all the intermediate stages of transformation of the materials which are taken in by the living body into the materials which are given out from it. But since the initial processes and the final results are the same as they would be on the assumption that the changes are brought about in conformity with the known laws of chemistry and physics, we may fairly conclude that all changes in living substance are brought about by ordinary chemical and physical forces."—Sir Edward Schäfer, President's Address at the Dundee Meeting, British Association Report, 1912, p. 9.

60 R. Meldola, "The Chemical Synthesis of Vital Products" (Arnold, 1904), p. 7.

61 F. R. Japp, "Stereochemistry and Vitalism. Presidental Address to Section B (Bristol), British Association Report, 1898, p. 826; *cf.* K. Pearson, NATURE, 1898, lviii, 495; G. Errara; F. R. Japp. *ibid.*, 616; Ulpiani and Condelli, *Gazz. chim. ital.* 1900, xxx [i], 344; Byk, *Ber.*, 1904. xxxvii, 4696; Heule and Haakh. *Ber.*, 1908, xli. 4261; Byk, *Ber.*, 1909, xlii, 141.

62 *Cf. inter alia*, McKenzie, Trans. Chem. Soc., 1905, lxxxvii, 1373.

63 I. von Ostromisslensky, *Ber.*, 1908, xli, 3035.

64 E. Erlenmeyer, Biochem Zeitsch., 1913, lii, 439.

65 *Cf.* J. Wislicenus, "Ueber die räumliche Anordnung der Atome in organischen Molekulen" (Leipzig bei S. Hirkel, 1889), 28; K. Auwers and V. Meyer, *Ber.*, 1888, xxi, 791.

66 J. H. Aberson, *Ber.*, 1898, xxxi, 1432; P. Walden, *Ber.*, 1899, 32, 2720.

H	H	H
$OH.\dot{C}.CO_2H$	$OH.\dot{C}.CO_2H$	$OH.\dot{C}.CO_2H$
|	|	|
$CO_2H.\dot{C}.H$	$H.\dot{C}.CO_2H$	$H.\dot{C}.H$
H	H	CO_2H
laevo-acid, $[a]_D - 5.8°$	(not isolated)	(Aberson's acid, $[a]_D + 9.8°$

With the inactive asparagine it is supposed by Erlenmeyer that prolonged heating in aqueous solution produces a rotation of this type, possibly to an unequal extent or in opposite directions in the *dextro-* and *laevo-*forms, whereby the products being no longer antipodes become separable by ordinary laboratory methods. It is too early yet to say whether, by exclusion of all asymmetric influences, the riddle has been solved, but it is easy to understand with what interest confirmation of Erlenmeyer's results is awaited.

Honours Students and Post-Graduate Scholarships.

In bringing this address to a conclusion, it will not be an innovation if I refer—it shall be only briefly—to the training of those who will carry on and amplify the work which we in this generation have attempted to do. This section stands for the advancement of chemistry which includes, so closely are pure and applied chemistry intertwined, the advancement of chemistry as applied to industry. Once again the cry has been raised in the Press[67] that chemists trained in our universities are of little value in industrial pursuits; they are too academic; they are not worth their wage—little as that often is, whether judged by a labourer's hire or the cost of a university training. It may be so. On the other hand, it is possible the employer obtains all that he pays for, and by paying more would receive in return much more by the inducement offered to more highly trained men to enter the field. Three years' training for the ordinary degree cannot carry a student very far in chemistry, and this preliminary training—for it is little more—is insufficient to equip the young graduate for more than routine work. With the honours student it is otherwise. He must either enter on his three years' residence at a university with a knowledge which does not fall below the requirements of the intermediate examination, and devote the greater part of his time to his honours subject, or he must be prepared to spend a fourth year to reach the necessary standard. More highly equipped in the academic sense than a man who has worked only for the ordinary degree, he undoubtedly is, yet there is seldom time to begin his training in research methods or in methods of commercial analysis where rapidity rather than extreme accuracy is the object in view.

Two reforms, I venture to think, are needed: the first would avoid early specialisation, which is apt to be disastrous, the second would encourage post-graduate training in directions where the student's inclinations or aptitude may be stimulated and developed. If the civic universities, established in virtue of charters drafted mainly on similar lines and inspired by similar aims, could come to some agreement requiring three years' residence, subsequent to the intermediate, for an honours degree in chemistry, the first reform would be effected—it is a measure for which a strong case can be made out. If, further, they could see their way to standardise their ordinances and regulations for the M.Sc. degree, cease to confer it on honours graduates of one or more years' seniority in return for payment of a fee, and confine it to graduates—not necessarily honours graduates—who have carried out an approved piece of research during not less than one academic year, selection committees, boards of directors, or individual employers would have some clue to the type of man before them. I would go further and suggest that the interchange of honours graduates between the civic universities, or between them and other universities or colleges, if it could be arranged, would be of much benefit to the student himself. No university in this country is wealthy enough to attract to its service teachers who are pre-eminent in each branch of chemistry. How great, then, would be the gain to an honours graduate working for the M.Sc. degree, if, instead of being associated with the same teacher during the whole of his academic career, he could migrate from the place which had trained him to spend part, or the whole, of his time in the laboratory of an Armstrong, a Donnan, a Perkin, or a Ramsay, during that most critical period when he is sorting out his own ideas and learning how to use his fingers and his wits. But whether enforcement of the longer training for the honours degree be possible; whether a research degree as a step to the doctorate be desirable or practicable, there can be no doubt that the urgent need of the present time is the provision of scholarships and exhibitions, sufficient in value to secure at least a bare livelihood, for post-graduate work. He who is able to convert education committees and private donors to the view that a far better return for the money could be assured if part of the large expenditure on scholarships for matriculated or non-matriculated students were diverted to post-graduate purposes, will have done a service to science and the State the value of which, in my opinion, cannot be overestimated.

67 Cf. *The Times*, Engineering Suppl., 1913, May 7, 21, 28, June 4, 11, 18.

NOTES.

WE announce, with deep regret, the death, on Thursday last, of Sir Walter Noel Hartley, F.R.S., formerly professor of chemistry at the Royal College of Science, Dublin. He was in the sixty-eighth year of his age.

PROF. ARMINIUS VAMBÉRY, the Oriental scholar, died at Budapest on September 14, in his eighty-second year. The obituary article on him in *The Times* states that in 1861 the sum of 1000 florins was voted to him by the Hungarian Academy of Sciences on condition that he went into the interior of Asia to investigate the affinities of the Magyar tongue. In the following year he left for Persia, joining a caravan of Tartar pilgrims returning from Mecca. In no way intimidated by predictions of privations and dangers or by the melancholy fate of Conolly, Stoddart, Moorcroft, and others, he decided to maintain throughout the journey a strict disguise as a dervish. Leaving Teheran on March 28, 1863, Vambéry reached Khiva at the end of May, after intense sufferings from thirst in the trackless desert. In 1864 he visited London, gave an account of his travels at a meeting of the Royal Geographical Society, and did his best to convince public men in England of the necessity for the creation of a neutral zone or a geographical buffer State in Central Asia.

THE death is announced at Chatham, Ontario, of Dr. Alex. MacFarlane, in his sixty-third year. A native of Blairgowrie, he graduated at Edinburgh in

1875, after a brilliant University career. The thesis by which he obtained the doctorate in 1878 was a remarkable experimental research into the conditions governing the electric spark. This brought him under the notice of Clerk Maxwell. In the same year he was elected F.R.S. Edinb. In 1885 Dr. MacFarlane was appointed to the chair of physics in the University of Texas. About fifteen years ago he took up his residence in Canada, where he continued to be actively engaged in physical and mathematical research. The latest of his many publications was a "Bibliography of Quaternions," issued in 1904.

ONE of the passengers killed in the disastrous New Haven Railway collision, which occurred on the same day as that at Aisgill, was Dr. Joseph Benson Marvin, professor of medicine and neurology at the University of Louisville. Dr. Marvin was born in Florida in 1852. At the age of eighteen he was appointed assistant professor of chemistry and physics at the Virginia Medical Institute. He then took a medical course, and afterwards held professorial posts at the Louisville Hospital College of Medicine, the Kentucky School of Medicine, and Kentucky University successively. Dr. Marvin's wife and daughter, who had been with him on a holiday in Maine, were also victims of the disaster.

CHANGES in the staff of the Central Research Institute at Kasauli are announced. Major W. F. Harvey, I.M.S., is taking the place of Sir David Semple as head of the institute, and Capt. J. W. McCoy, I.M.S., is to join the bacteriological department.

A BOARD for the study of tropical diseases has been established at Ponce, Porto Rico, by the Medical Department of the United States Army. The first president of the board is to be Major B. K. Ashford.

ACCORDING to *The Times*, arrangements are being made for an expedition to King Edward the Seventh's Land, in the south polar region, to start in August next. The leader is to be Mr. J. Foster Stackhouse, who was associated with Capt. Scott in organising the voyage of the *Terra Nova*. The present arrangements are that the members of the expedition shall sail from the Thames about the middle of August in the steam yacht *Polaris*, a ship especially built for ice navigation in accordance with designs approved by an international committee of explorers, including Charcot, de Gerlache, and Nansen. It is contemplated that the expedition will be absent for twenty months or more.

PARTICULARS of the plans of the Italian expedition to the Himalayas, which is to be led by Dr. Filippi are given in *The Pioneer Mail*. According to our contemporary the explorers will work in Karakoram throughout the summer of 1914, spend the autumn in Chinese Turkestan, and leave for Europe by about Christmas. It is the object of the leader to carry out observations across Chinese Turkestan into Russian Turkistan, to winter in Scardo in Baltistan, and early in the spring of 1914 to travel by the inner Indus valley to Leh. From the latter place the expedition will leave for the Karakoram district to survey and map the unknown portion of the Karakoram range which lies between the Karakoram pass and the Siachen glacier. The Government of India, which has subscribed 1000*l*. towards the funds, has appointed Major Woods, of the Trigonometrical Survey, to accompany the expedition.

AMONG the communications to be made at the forthcoming meeting of German Naturalists and Medical Practitioners, at Vienna (September 21–28), we notice the following:—An address by Prof. von Behring on the prophylaxis of diphtheria, and papers on the development of the light and colour senses in the animal kingdom, vision, and the problem of race crossing in man by, respectively, Profs. von Hess, O. Lummer, and E. Fischer.

THE seventeenth annual fungus foray of the British Mycological Society, lasting a week, is to begin at Haslemere on September 22. The meeting place of the party will be the Hutchinson Museum. On September 24 the presidential address will be delivered by Mr. A. D. Cotton, who will take as his subject, "Some Suggestions as to the Study and Critical Revision of Certain Genera of Agaricaceæ." On the following day a paper, entitled "Recent Work on Resupinate Theleshoreæ," will be read by Miss E. M. Wakefield, and on September 26 Mr. J. Ramsbottom will read a paper entitled "Some Notes on the History of the Classification of the Discomycetes."

THE twenty-fourth annual general meeting of the Institution of Mining Engineers is to take place at Manchester on September 24–26, when the following papers will be read, or taken as read:—"A Method of Measuring Goaf Temperatures," T. F. Winmill; "The Absorption of Oxygen by Coal," T. F. Winmill; "Dust Problems in Mines and their Solution," Hermann Belger and A. Owen Jones; "Further Researches in the Microscopical Examination of Coal, especially in Relation to Spontaneous Combustion," James Lomax. In addition to the foregoing, the following papers, which have already appeared in the Transactions, will be open for discussion:—"Recent Methods of the Application of Stone-dust in Mines," Dr. W. E. Garforth; "The Reopening of Norton Colliery with Self-contained Breathing-apparatus after an Explosion," J. R. L. Allott; "The Slow Oxidation of Coal-dust and its Thermal Value," F. E. E. Lamplough and A. Muriel Hill; "Insulated and Bare Copper and Aluminium Cables for the Transmission of Electrical Energy, with Special Reference to Mining Work," B. Welbourn. In connection with the meeting a lecture on explosion experiments at Eskmeals will be given on September 25 by Prof. H. B. Dixon, F.R.S.

WE understand that the title of Prof. W. Ostwald's journal, *Annalen der Naturphilosophie*, has been changed to the more comprehensive one of *Annalen der Natur- und Kulturphilosophie*; also that Prof. R. Goldscheid is now associated with Prof. Ostwald in editing the periodical.

THE correspondent of *The Times* at Rome reports an interesting discovery made by Mr. Adolfo Cozza in excavating at Pompeii with the object of tracing the site of the port where, in his opinion, threefourths of the population sought escape from the eruption of Mount Vesuvius, hoping that the Roman fleet would be able to remove them into safety. After various try-pits had been sunk he discovered plaster and concrete, and finally a road leading to the sea showing signs of the passage of wheels. The masonry-work of a harbour was then unearthed with the marks left by the waves. The port which has just been discovered is at a distance of about 1300 yards from the existing seashore and about 700 yards from the ruined city. It is covered with a layer about 23 ft. deep, consisting of earth, lava, ashes, and *lapilli*. Further excavations will, it is thought, bring to light the skeletons of the majority of the population of Pompeii as well as treasures of gold and works of art.

A LARGE Etruscan necropolis, containing several skeletons, as well as vases and terra-cottas, dating from the seventh century B.C., has been discovered near Civita Vecchia in Italy, on the coast of Latium.

A CURIOUS story comes from Ireland that Mr. E. S. Dodgson, of Jesus College, Oxford, has discovered at Killult, Falcurragh, Donegal, a stone said to contain an Ogham inscription giving a clue to a great treasure concealed in the neighbourhood by an ancient Irish chieftain. The stone is being examined by Mr. R. Macalister. We wish the discoverer success in unearthing the treasure, but until he succeeds, or some other interpretation of the supposed inscription is suggested, it may be well to reserve opinion on the matter.

A RECENT message from San Francisco stated that the Falcon and Hope Islands of the Tonga group had disappeared. The information was brought by Capt. Trask of the steamship *Sonoma*, from Sydney, who is reported to have said:—"One of the regular trading steamships between Sydney and the Tonga group reported the sinking of the islands. The vessel steamed to where Falcon Island should have been, but it was nowhere in sight. Just before this the instruments at Sydney naval station showed that several violent earthquake shocks had taken place about 2000 miles north-east of Sydney." With reference to the foregoing message, Mr. Basil A. Thomson (who acted for a time as Prime Minister of Tonga), wrote to *The Times* on September 14 that the news should be received with reserve for the reasons, "first, that Falcon had already ceased to exist as an island fourteen years ago; and, second, that Hope Island, better known by its native name of Niuafo'ou ('New Niua'), is reported to have disappeared whenever a serious volcanic disturbance shakes the nerves of the white residents of Tongatabu."

THE Museum Journal of the University of Pennsylvania announces in its March issue the despatch of an expedition, under charge of Dr. Farabee, to explore the primitive tribes of the Amazon forests. The Brazilian Government promises active assistance to Dr. Farabee and his staff. From Para they will proceed to Manaos, and from thence ascend the Rio Negro, the largest tributary of the Amazon from the north-west. The examination of this region will occupy the attention of the expedition for six months or perhaps a year. The collections to be made will consist of weapons, utensils, and all objects relating to the arts of life procurable among the various tribes to be visited. They are destined to supply material for future research, and especially to enable the museum to reproduce the actual life of some of the most interesting native tribes, soon destined to disappear.

IN No. 2, vol. xxiv., of *Folk-lore* we have the final, but unhappily fragmentary, dissertation by the late Mr. Andrew Lang, in which he develops his theory of the origin of exogamy and totemism. Following Darwin, he assigns the beginnings of exogamy to the expulsion by the sires of the group of the younger males. He assumes that the establishment of totemic groups and practices cannot have been sudden; men cannot have, all in a moment, conceived that each group possessed a protective and sacred animal or other object. But if each group woke to the consciousness that it bore the name of a plant or animal, and did not know how it came to bear that name, no more was needed to establish a belief in the essential and valuable connection of the group with certain animals, birds, or other objects. These names, he thinks, originated in sobriquets given by one group to another. In this exposition he is in general agreement with the views of Dr. A. C. Haddon in his address delivered before the British Association at the Belfast meeting in 1902.

IN *Man* for September Mr. W. J. Lewis Abbott describes a collection of pygmy flint implements made by Mr. J. M. Bain from the base of the sand-dunes at Fishook, Cape Colony. They closely resemble the series presented by Miss Nina Layard to the Ipswich Museum. Mr. Abbott believes that this is the result of culture-transmission. "It is obvious," he believes, "that the prototypes of these shapes could not have arisen in a country where the native material did not lend itself to their manufacture; but in one where a homogeneous silica, such as flint, was the common indigenous material; and in following up the search for these interesting little objects, we shall be getting together the material to show the migrations of this old race over the face of the earth, and perhaps be able to trace it to its cradle."

IN the Philadelphia Museum Journal for June Dr. Arno Poebel, of Johns Hopkins University, announces an important discovery among the collection of clay tablets obtained at Nippur during the years 1888–1900, which are now being arranged for exhibition. One tablet, unfortunately imperfect, gives a version of the Creation story, in which the origin of the first human beings is attributed to the gods Enlil and Enki, and the goddess Ninharsagga—a question which has led to much speculation among Assyrian and biblical scholars. In the present version, when Enlil, the creator of heaven and earth, wished to people the world with human beings, the god Enki, the deity of wisdom and knowledge, devised the image of man after the image of the gods, and the goddess Ninharsagga moulded it in clay, while the blood of Enlil gave it life and intellect. Whether the idea that Enlil cut off his head will be corroborated from other cuneiform sources we cannot tell at present. Meanwhile the present discovery is obviously of the highest importance.

IN the May number of *The Irish Naturalist* (vol. xxii., No. 5), Mr. N. Colgan gives an interesting account of the renascence flora of certain areas on Killiney Hill, Co. Dublin, formerly covered with old gorse but burnt out in July, 1911. Three months after the fire the burnt areas showed thirteen species of flowering plants, partly survivals from old root-stocks, partly immigrants from adjacent unburnt areas, and partly perhaps the product of seeds that had retained their vitality throughout the fire. Later observations showed that eighteen months after the fire a renascence flora of sixty-four species, including nine cryptogams, had taken possession of the areas burnt clear of all vegetation. Of these species, forty-five had certainly or very probably entered from adjacent unburnt areas, thirteen were survivals, and the remaining six could not with certainty be placed among either immigrants or survivals, and are classed as of doubtful origin. The cryptogams covered much more ground than the flowering plants, the most abundant species, dominating above all other plants in the burnt ground flora, were the mosses *Funaria hygrometrica* and *Barbula fallax*; other common bryophytes were three species of Polytrichum and the liverwort *Marchantia polymorpha*; while two species of the lichen genus Parmelia were also frequently found. Among the phanerogamic immigrants the grasses were strongly predominant, and the immigrant flora as a whole consisted largely of plants provided with special adaptations for seed dispersal, one of the most prominent of these plants being *Senecio sylvaticus*. The most interesting fact arising from this new flora is the conflict between its higher and lower members, the phanerogams and the cryptogams, the latter having so far kept in check the much more varied phanerogamic flora. The probable successive changes in the vegetation are outlined by the author.

WE have received a reprint of an interesting paper by Dr. C. B. Crampton, "The Use of Geology to the Forester" (*Trans. Argyll Foresters and Gardeners*, 1912), pointing out some of the geological facts that have a bearing upon the nature and origin of the various types of surface occupied by plants, and emphasising the importance to foresters in particular of a knowledge of the nature of the ground under his charge in so far as it reacts with the vegetation, and the reasons for differences in the surface and in these reactions. The author indicates the geographical and geological factors upon which depends the nature of a habitat for trees or other plants, with special reference to the action of gravity in screes and landslips, the erosive action of wind and streams, coastal erosion, glacial erosion and deposition, and the characters of soils and subsoils.

IN a recent number of *The Herts Advertiser* it is stated that, in consequence of Dr. Sambon's remarks on pellagra at a recent meeting of the British Medical Association, Dr. Blandy, of the Lunatic Asylum at Napsbury, near St. Albans, undertook an examination of the patients in that institution, with the result that no fewer than eleven were found to be suffering from that disease. As the majority of these come from the moist, low-lying district of the Colne Valley, support is afforded to the opinion that the disease is propagated by insects.

As a result of the examination of the large series of specimens of mammals and birds collected in East Africa by the Roosevelt and other American expeditions, very considerable additions have been made recently to the list of species and races from that area, the descriptions having been published for the most part in various issues of the Smithsonian Miscellaneous Collections. The latest of these papers include one by Mr. E. Heller (vol. lxi., No. 7), on new races of antelopes, and another, by Mr. E. A. Mearns (*ibid.*, No. 9) on new weaver-birds. As regards the antelopes, it must suffice to mention that some of the new races are founded on very slight differences from previously known forms, and it is thus rendered difficult to see where the modern fashion for excessive splitting is to stop.

IN connection with the preceding paragraph, it may be mentioned that in the current issue of the Zoological Society's Proceedings three additions are made by Messrs. Barrett-Hamilton and Hinton to the British mammal-fauna, all three being from the Inner Hebrides. The most interesting of these is a shrew-mouse (*Sorex granti*), distinguishable at a glance from the common English *S. araneus* by the contrast presented by the light-coloured flanks to the dusky upper parts. As it also exhibits certain dental peculiarities, its right to specific rank seems undoubted. The other are field-mice; one (*Evotomys alstoni*) a species from Mull, and the other (*Microtus agrestis macgillivraii*) a race from Islay.

THE September number of *The Museums Journal* contains an illustrated account of Mr. J. A. C. Dean's method of "showing" objects in museums and art galleries to blind persons, as explained at the Hull meeting of the Museums Association. The method appears to have attained considerable success, and to have awakened a new interest in the class for which it is intended. It may be remarked—as indeed was hinted by the president at the close of the discussion—that if this mode of demonstration is adopted in up-to-date zoological museums it will be necessary for each to have a separate series of stuffed specimens for this purpose.

IN the *Verhandlungen der Naturforschenden Gesellschaft in Basel* (Bd. xxiv.) will be found a paper by the late Fr. Burckhardt, entitled "Die Stellung des Osterfestes im christlichen Kalender." It is a contribution to the historical side of the question, and contains several original documents of some interest. An extract from the writings of Luther is given, in which he advocates a fixed date for Easter, not merely without regard to the moon's phases, but also, like Christmas, without regard to the days of the week. Other documents refer to the adoption of the reformed calendar by the Protestants in Switzerland. Practical convenience forced them to follow the Gregorian calendar in the main, though not until the end of the seventeenth century, and even then one difference was maintained. This arose from basing the calculation of the Easter full moon on the Rudolfine Tables instead of the Gregorian Epact. The first discrepancy occurred in the year 1724, when the Gregorian full moon fell on Sunday, April 9, while the Tables gave the day preceding. The question was referred for decision to the Protestant Conference at Ratisbon early in 1723, and the Basel authorities sought the advice of John Bernoulli. The replies are reproduced in full. In the result Easter was celebrated by Catholics and Protestants on successive Sundays in 1724 and again in 1744. Agreement was finally brought about by an order of Frederic the Great in 1776 on the basis of the Gregorian calendar. The desirability of a fixed Easter has been commonly felt from the time of the Gregorian reform, and it was the last act of Father Denza, late director of the Vatican Observatory, to prepare a memorandum on the subject for Pope Leo XIII. His proposal was to adopt the third Sunday following the vernal equinox, which would limit Easter between April 4 and 11.

THE Director-General of Observatories (India) has issued a memorandum dated August 9 on the monsoon conditions prevailing during June and July, with anticipations for August and September. From the recent data regarding the conditions most likely to be of influence, and which are stated in detail, the unfavourable factors appear to predominate slightly. But the inferences drawn are (*a*) that the total rainfall of the months in question will probably be normal or in slight defect, (*b*) that in north-west India the monsoon is not likely to be affected prejudicially by snowfall. (The fall of temperature and dry north-westerly winds that usually follow widespread and heavy snowfall have not been experienced.) The above forecast agrees practically with that issued on June 8 (NATURE, August 7).

DR. NILS EKHOLM has contributed an important article on the weather in the North Sea during the first half of June, 1911, illustrated by synoptic charts, to No. 64 of the Occasional Publications issued under the authority of the International Council for the Study of the Sea. The period is chosen because the council had then six hydrographical expeditions stationed in that sea. The author prefaces his inquiry by a careful historical summary of the development of meteorology and its methods from the invention of the barometer to the present time, and with a description of barometric changes and their relation to wind and weather, in which we were pleased to see that the valuable pioneer work of Admiral FitzRoy, the first chief of the Meteorological Office, is duly recognised. The author explains that the difficulties with which modern conceptions of cyclones and anticyclones have to contend led him to supplement the usual isobaric charts by plotting the ± differences of barometric readings since the last observation, and thus constructing "isallobars," or lines of equal differences. He remarks, *inter alia*, that a close study of the movements of the isallobars shows that pressure changes are the primary, and cyclonic and anticyclonic whirls the secondary phenomena. The charts for the North Sea for the above period and two other cases are discussed upon those principles.

DR. H. GEIGER, of the Reichsanstalt, who four years ago, in conjunction with Prof. Rutherford, devised a method of counting the number of α particles emitted by a radio-active body, has now, according to a communication from the Reichsanstalt, succeeded in perfecting a very simple method which allows both the α and β particles to be counted. The α or β rays are allowed to enter a short metal cylinder 2 cm. diameter, by a small hole in the base. Through an ebonite block which closes the other end of the cylinder a sharp pointed rod projects into the cylinder to within 0·8 cm. of the base. The cylinder is raised to about 1200 volts, and the pointed rod is connected to a string electrometer provided with a high-resistance leak. The entry of either an α or a β particle into the cylinder causes a spark to pass between point and cylinder, and the electrometer of 10 cm. capacity acquires a charge corresponding to 10–20 volts. The throws of the electrometer are recorded photographically, and the results obtained are in agreement with those calculated from ionisation observations in the case of the polonium preparation used in the observations.

Engineering for September 5 contains an illustrated account of the Sulzer-Diesel locomotive built by Messrs. Sulzer Brothers at Winterthur, in the early part of this year, and supplied to the Prusso-Hessian State Railway, Berlin. This is the first locomotive fitted with Diesel engines, and is designed for fast traffic. The length over-all is 54·5 ft., and the weight in working order is 95 tons. The main engines are of the reversible two-cycle type, single-acting, having two pairs of cylinders inclined at 90° to each other. The pistons are 15 in. diameter by 21·7 in. stroke. Running at 304 revolutions per minute, a speed of sixty-two miles per hour is obtained. The auxiliary machinery required is of a somewhat complicated character. Trials have been made, and show that the engine is adaptable to a wide range of work. It is reported that the change from air to oil-fuel is accomplished without trouble at a speed of about six miles per hour, and that the reversing arrangements were equally successful.

Engineering of the same date has an article dealing with problems of the internal-combustion locomotive, in which further reference is made to the Sulzer-Diesel locomotive. Our contemporary considers that any locomotive engineer reading the full description of this engine would be somewhat appalled at the extraordinary amount of machinery the type involves. The main engine requires another engine, of one-quarter or one-fifth of its power, to make it start at all. The second engine, also of Diesel type, requires similar provision in the way of air and circulating-water supply, &c., to the main engines, involving pumps for the supply of starting air, scavenging air, injection air, fuel to each cylinder, jacket water, circulating water for pistons, and for lubrication of bearings, &c. A comparison of this collection of machinery with that in a modern steam locomotive is greatly in favour of the latter. Neither does the Diesel locomotive appear to show up any too well as a power plant; one horse-power is developed for about 190 lb. weight. A modern steam locomotive develops one horse-power for about 100 lb. of engine weight, or for every 140 to 150 lb. of combined engine and tender weight. Rapid perfecting of this type of engine is not to be expected, but it is to be hoped that the efforts instituted on the Continent will be persisted in. The greater the initial handicap, the more glorious the ultimate victory.

ATTENTION may be directed to a slight error in the date assigned to Messrs. Cartailhac and Breuil's monograph on "La Caverne d'Altamira"; the frontispiece bears the date 1906, but this work was not published until 1908.

OUR ASTRONOMICAL COLUMN.

THE ROTATING ELLIPSOID RU CAMELOPARDALIS.—The elaborate investigations recently carried out by Prof. H. N. Russell upon the treatment of photometric observations of variable stars have been the means of bringing to light a new class of these bodies. By taking into account the hypothetical, but, of course, quite possible ellipticity of the components of a binary system, a method was developed which may be applied equally well to the case of an isolated rotating ellipsoid—an early stage in the development of a binary system. At Princeton during the last two years the light changes of three stars—S Antliæ, SZ Tauri, and RU Camelopardalis—have been explained in the most satisfactory way on the hypothesis that they are rotating ellipsoids. In Bulletin No. 21 of the Laws Observatory Mr. Harlow Shapley discusses 292 photometric measures of the third of these stars, and comes to the conclusion that "the light variations . . . can be satisfactorily accounted for on the hypothesis of a single, uniformly luminous, ellipsoidal body rotating in a period of 44·344 days." With regard to the spectrum of this star the author quotes a letter from Prof. E. C. Pickering to the effect that it is peculiar and apparently variable, and that Miss Cannon thinks it may belong to class N.

The publication of the curves and results for S Antliæ and SZ Tauri is promised for the near future. As both these stars have spectra of classes much less prone to variability of a physical character the realisation of this promise will be awaited with great interest.

THE DIMINUTION OF THE SOLAR RADIATION IN 1912.—Further evidence regarding the existence of a widespread atmospheric opacity during 1912 appears in a note by M. Ladislas Gorczynski in the *Comptes rendus* (vol. clvii., No. 1). The pyrheliometer record made at Varsovie shows that during the latter half of the year there was a marked falling off in the intensity of the solar radiation. The detailed measures, we are informed, show that the depression lasted from about the middle of June, 1912, to the middle of January, 1913, and was most severe in September. Similar results were obtained at the Meteorological Observatory of Olczedajów, and it is pointed out that analogous records were obtained at Mount Weather.

COMET 1913*b* (METCALF).—A supplement to *Astronomische Nachrichten,* No. 4679, contains a continuation of the ephemeris of this comet which was given last week, after the first approximate elements computed by Prof. Kobold. The comet is slowly increasing in brightness, according to the ephemeris, but on September 3 it was observed as of magnitude 9·5, and on September 4 as of magnitude 10·0.

12h. M.T. Berlin.

	R.A. h. m. s.	Dec. ° ′	Mag.
Sept. 18 ...	6 6 18 ...	+67 23·5 ...	—
19 ...	6 0 47 ...	68 8·6 ...	10·3
20 ...	5 54 43 ...	68 54·0	—
21 ...	5 47 58 ...	69 39·4	—
22 ...	5 40 26 ...	70 24·3	—
23 ...	5 32 2 ...	71 8·8	10·3
24 ...	5 22 42 ...	71 52·9	—

COMET 1913*c* (NEUJMIN).—This comet when first observed (September 3) was thought to be a minor planet, but later observation has suggested its cometary nature. Herr M. Ebell has computed the elements from the observations of September 6, 7, and 8, and these, with an ephemeris, have been communicated in a Kiel circular. They are as follows:—

T = 1913 July 22.5755 M. T. Berlin.

$$\left.\begin{array}{l}\omega = 320^\circ\ 56{\cdot}70' \\ \Omega = 347^\circ\ 19{\cdot}42' \\ i = 12^\circ\ 22{\cdot}97'\end{array}\right\} 1913{\cdot}0.$$

$\log q = 0{\cdot}11296$

Ephemeris for 12h. M.T. Berlin.

	R.A. h. m. s.	Dec. ° ′	Mag.
Sept. 18 ...	22 43 10 ...	+4 9·3 ...	—
19 ...	22 42 40 ...	4 27·7 ...	—
20 ...	22 42 10 ...	4 45·5 ...	11·2

According to Dr. Graff, at Bergedorf, the comet showed a short tail on September 6, but on September 8, from observations made at Pulkova, the object was recorded as stellar.

NEW LABORATORY SPECTROSCOPIC RESULTS.—The physical laboratory of the Imperial College of Science and Technology is responsible for four different spectroscopic researches recently communicated to the Proceedings of the Royal Society (Ser. A., vol. lxxxix., pp. 125–149). Mr. L. C. Martin, a research student, writes on a band spectrum attributed to carbon monosulphide, and has found a new spectrum consisting of a number of bands degraded to the less refrangible side, the wave-lengths of which he gives in his paper. Prof. Fowler records new series of lines in the spark spectrum of magnesium incidentally tying up the well-known spark line at λ4481 in one of the series. In conjunction with Mr. W. H. Reynolds, research student, Prof. Fowler has another paper on additional triplets and other series lines in the spectrum of magnesium. Eight additional triplets have been measured in the spectrum of magnesium arc *in vacuo,* six belonging to the diffuse and two to the sharp series. Four additional members of the Rydberg series of single lines have been photographed, and four strong solar lines of unknown origin have been identified with lines of the Rydberg series. Two known lines, 5711·31 and 4730·21, have been coupled up in a series with 4354·53, a previously unrecorded line. Mr. W. E. Curtis, the demonstrator of astrophysics, has a paper on a new band spectrum associated with helium, but the question of its origin is still doubtful, as hydrogen was present in all the tubes examined. A list is given of the wave-lengths determined. A search in celestial spectra was made, owing to its association with helium, but the result was negative.

THE PERTH OBSERVATORY SECTION OF THE ASTROGRAPHIC CHART.—Vols. ii. and iii. of the Perth Observatory (Western Australia) section of the astrographic chart have just come to hand. These volumes are two out of the thirty-six volumes which will be published. The region of the sky assigned to this observatory lies between 31° and 41° S. declination, and the photographs have been taken and measured under the direction of Mr. W. Ernest Caske, the Government Astronomer for Western Australia. Vol. ii. contains the measures of rectangular co-ordinates and magnitudes of 20,211 star images, R.A. 6h. to 12h., on plates with centres in declination −32°, and vol. iii. those of 20,988 images, R.A. 12h. to 18h., on plates with centres also in declination −32°.

The completed work will be a valuable contribution to the great international scheme, initiated so many years ago. Incidentally a number of double stars were met with during the measurement of the zone plates, and these, 242 in number, have been collected and published in a separate catalogue, forming Bulletin No. 1. The reduction of the measures was undertaken by Mr. Nossiter, acting first assistant.

THE EXTENSION OF THE ZONE TIME SYSTEM.—Brazil has now officially fallen into line by adopting standard time. The country has been divided into four zones, and the legal time for each respectively will be two, three, four, and five hours slow on Greenwich. The islands of Trinidad and Fernando Noronha fall in the first zone. The western side of the second zone is a line from Mount Pecuary Grevaux, on the French Guiana boundary, by the rivers Pecuary and Javary to the Amazon, and by Xinsu to the Matto-Grasso boundary. The fourth zone includes the western part of Amazonas, the Acre territory, and other territory recently ceded by Bolivia.

HIND'S NEBULA.—M. Borrelly has communicated to the Academie des Sciences (*Comptes rendus,* vol. clvii., No. 7) a brief note stating that the nebula discovered by Hind in the year 1845 (No. 6760 in Dreyer's N.G.C.) and suspected of variability of brightness seven years later by d'Arrest, now appears to be in a period of maximum. For the first time since 1867 it is easily seen with a comet-seeker of $6\frac{1}{2}$ in. aperture.

THE ROYAL OBSERVATORY, CAPE OF GOOD HOPE.—The annual report of his Majesty's Astronomer at the Cape of Good Hope for the year 1912 has been received. In connection with the reduction of the circumpolar observations made in the previous year some interesting determinations of personality have been made. It appears that, while with the older methods of observing, transits of equatorial stars are mostly recorded *late,* transits of slow-moving circumpolars are *anticipated* by 0·3s. The astrophysical work has been actively advanced, both in the observatory and laboratory. Provisional spectroscopic determinations of solar parallax and the constant of aberration, based as the measures of 800 plates, yielded $8{\cdot}802'' \pm 0{\cdot}004''$ as the value of the former, and $20{\cdot}47'' \pm 0{\cdot}01''$ for the latter. In the laboratory it has been found more convenient to employ the spark spectrum obtained from the cores of lead pencils as a comparison spectrum in preference to the spectra of iron or titanium.

A CURIOUS METEORIC DISPLAY.

THE universal disappointment experienced by keen meteor observers on the expected return of the November Leonid meteor swarm in 1899, the swarm which created such a stir of excitement at its appearance in the year 1866, is no doubt responsible for the apparent lack of interest taken in the announcements of probable meteoric displays to-day. Many of us thought that this celebrated display, due possibly to planetary perturbations, might be accelerated, and so were careful to keep a good look-out in the appointed month in 1897 and 1898, and their non-appearance in 1899 suggested that possibly, for a similar reason, the swarm might have been belated, and so watched at the correct season for the overdue display. The expected event did not take place, and faith was lost in the predicted times of these space wanderers.

Our interest is, however, again wakened by what is described as "an extraordinary meteoric display" which was seen over a very extensive area in the United States of America and Canada on the evening of February 9 this year. The magnitude of the display was such that a very great number of people distributed in the path of observation had their attention drawn to it, and its peculiar nature was so marked that nearly every observer remarked similarly of the extraordinary feature of the event.

Fortunately Prof. C. A. Chant, of Toronto, although not an eye-witness of the phenomenon, undertook to collect all the available information of this very exceptional, if not unique, occurrence. In the May–June number of the *Journal* of the Royal Astronomical Society of Canada he presents a very judicious summary of the observations made, and accompanies this with extracts from letters received from observers.

The sum total of the discussion of the data is to show that the apparition took the following form:—

As seen from western Ontario there suddenly appeared in the north-western sky a fiery red or golden-yellow body, which quickly grew larger as it approached, and had attached to it a long tail; observers vary in their descriptions as to whether the body was single or composed of three or four parts with a tail to each part.

This body or group of bodies moved forward on an apparently perfectly horizontal path "with peculiar, majestic, dignified deliberation; and continuing its course without the least apparent sinking towards the earth, it moved on to the south-east, where it simply disappeared in the distance." After this group of bodies had vanished, another group emerged from precisely the same region. "Onward they moved, at the same deliberate pace, in twos or threes or fours, with tails streaming behind them, though not so long or bright as in the first case." This group disappeared in the same direction. A third group followed with less luminosity and shorter tails.

In reading some of the communications from the numerous observers, the extraordinary feature of the phenomenon seems to have been the regular order and movement of the groups. Thus some compared them to a fleet of airships with lights on either side and fore and aft; others to a number of battleships attended by cruisers and destroyers; others again to a brilliantly lighted passenger train travelling in sections and seen from a distance of several miles.

Such descriptions indicate that the display was of a very unusual kind, very different from the usual quick-moving and scattered bodies. It may be of interest to reprint here in full one of the accounts. Mr. J. G. MacArthur writes:—

"There were probably thirty or thirty-two bodies, and the peculiar thing about them was their moving in fours, threes, and twos, abreast of one another, and so perfect was the lining-up you would have thought it was an aerial fleet manœuvring after rigid drilling. About half of them had passed when an unusually large one hove in sight, fully ten times as large as the others. Five or six would appear in two detachments, probably five seconds apart; then another wait of five or ten seconds, and another detachment would come into view. We could see each detachment for probably twenty or twenty-five seconds. The display lasted about three minutes. As the last detachment vanished, the booming as of thunder was heard—about five or six very pronounced reports. It sounded in the valley as if some of the balls of fire had dashed into Humber Bay. The bodies vanished in the south-east, but the booming appeared to come from the west or north-west, and the time it was heard was close to 9.12 p.m."

It is fortunate that Prof. Chant lost no time in gathering together all the available material concerning this unusual stream of meteors, and his communication is a valuable record for future reference, containing numerous charts and sketches and one coloured drawing.

THE BRUSSELS MEETING OF THE IRON AND STEEL INSTITUTE.

THE autumn meeting of the Iron and Steel Institute was held in Brussels from September 1 to 4, after an interval of nineteen years. It will probably rank as one of the most successful of the foreign visits ever paid by the institute, and the thanks of members and their wives are due to their Belgian hosts, whose forethought had provided for every contingency, and whose charming hospitality could not have been surpassed. The chairman of the reception committee was Mons. Adolphe Greiner, the managing director of the famous Société "John Cockerill," Seraing, a works founded by an Englishman of that name in 1817, and the international character of the Iron and Steel Institute is well illustrated by the council's selection of Mons. Greiner as the president-elect. It is customary at such foreign meetings for stress to be laid on papers dealing with the particular iron and steel industries of the district, and the discussions chiefly ranged round the contributions of the Belgian members. In an interesting historical survey of the metallurgy of iron in Belgium, Baron de Laveleye shows that Liége, Charleroi, and the central district are the principal centres of production, the first-named being "the true cradle of the industry." He gave it as his opinion that at the present day the workers in the Charleroi district are inferior to none in their aptitude and endurance. At the present time Belgium retains only 20 per cent. of her iron and steel products for home consumption, and exports 80 per cent., a larger proportion than that of any other country. This being so, she is compelled to accept as an average selling price that which rules in the international export market. The cost of production has certainly been brought down to a very low figure, and the author claims that it is "only by never allowing an improvement to be made without either adopting or trying it, by relying upon the energetic and hardworking labour classes to whom free trade supplies cheaply the necessaries of life, and by constantly increasing the productive capacity of their works that the ironmasters have succeeded in maintaining the struggle on an equal footing."

It was in Belgium that the first coke ovens were constructed which were heated at the side and underneath by the gas evolved from the coal during coking, and a paper by Baron Coppée, the son of Evence Coppée, the inventor of the oven bearing this name, dealing with modern processes of coke manufacture, was therefore of unusual interest. In Belgium the beehive oven has disappeared, and 97 per cent. of the coke is made in by-product ovens. On the other hand, in England the by-product oven has made less headway, partly because the first ovens erected were by no means as perfect as they are now, and produced a coke which was undoubtedly inferior to beehive coke, and partly on account of difficulties in connection with refractory materials which resulted in defective working of the ovens. In spite of the fact that most of the English bricks resist high temperatures as well as the continental varieties, according to the author they have the disadvantage of contracting at high temperatures, thereby causing cracks and dislocations in the structure of the ovens. The result is that all the leading constructors now use Belgian or German firebricks for those parts of their ovens which are in contact with the hot gases. By means of an apparatus which was on view during the meeting the author has tested numerous varieties of firebricks from the point of view of their expansion during heating, and has found that they vary considerably in this respect. Some of them appear to undergo no expansion above 700–800° C., and above this range to remain constant. This is the best result thus far obtained. In the discussion, however, one of the speakers claimed that the life of a good English brick is from seven to eight years. The modern trend in Belgium and Germany is to produce concurrently metallurgical coke and lighting gas, and at the present day the latter country has no less than forty-five towns or communes which are wholly or partially supplied with lighting gas derived from coke ovens.

Somewhat closely connected with the foregoing was a paper by Houbaer on the utilisation of blast-furnace and coke-oven gases in metallurgy. The application of the former to the development of motive power is a problem which has been solved for some time past. It is, however, only within the last few years that the utilisation of its calorific power for heating industrial furnaces has been taken into serious consideration, and the author passes in review its employment in heating metal mixers, open-hearth furnaces, and reheating furnaces. An arrangement has been adopted at the Deutscher Kaiser Steelworks for heating the three 1200-ton metal mixers with a single burner capable of taking either blast-furnace gas, coke-oven gas, or a mixture of both with air from the Cowper stoves.

Again, at the Bethlehem steelworks coke-oven gas is being applied as the heating fuel to a battery of six 75-ton open-hearth furnaces specially built with this object, and to an existing series of thirteen 60-ton furnaces. For many years calculations have been made as to the saving in fuel and advantages in working that may be expected to accrue from an artificial enrichment with oxygen of the air blown into a blast furnace. But in spite of the claims thus put forward, blast-furnace managers have hitherto refused to make the experiment, and with some reason, for the breakdown of such a furnace would be a very expensive matter, and the tendency has been to wait for someone else to make the test. A paper by Trasenster, presented at the meeting, indicates that the step has just been taken at the Ougrée-Marihaye works in Belgium. The oxygen plant is composed of three similar liquid-air units, each yielding 200 cubic metres of oxygen per hour. No results of working are given in the paper, but during the discussion the author stated that a month's trial had been run, in which the oxygen in the blast was raised to about 23 per cent. by volume. Moreover, a small blast furnace has been built in which the working will be carried out with very high percentages of oxygen, and even with pure oxygen. There is no doubt that these tests will be watched with the deepest interest, and in particular blast-furnace managers will desire to be informed as to how the difficulties which may be expected to result from increased temperature at the tuyeres are overcome. This is the main reason why they have been so much disinclined to make the experiments with their own plants.

Mr. Talbot, the inventor of the Talbot tilting furnace, presented a paper on modern open-hearth steel furnaces, in which he discussed the reasons which have militated against their adoption on anything like an extensive scale. The two main criticisms brought against them are the initial capital outlay and the increased cost of upkeep, and these the author sought to combat and to point out some of the principal advantages which in his opinion accrued from the use of tilting furnaces as compared with those of the fixed type. With a view to settling this question in a practical fashion, one of the largest continental steel-making firms is running in the same shop furnaces of both types under exactly similar conditions of shop practice, and it was clear from the discussion that until the results of this test are known most manufacturers prefer to adhere to the fixed furnaces the particular advantages of which are well known by this time.

It is characteristic of the rapid development of electric steel processes that scarcely a meeting of the institute is held without one or more papers on this subject. The paper by Otto Frick on the electric refining of steel in an induction furnace of special type marks a distinct development in the applicability of this type of furnace the use of which has hitherto been confined to the melting of high-class steels in which no refining took place. The results are based on the data obtained in the Frick furnaces at Krupp's works in Essen, which have been in operation for the last five years. With regard to the lining, the induction furnace offers certain intrinsic difficulties owing to the ring-shaped form of the crucible. On one hand greater difficulties arise in making the lining stand high temperatures without cracking, and on the other the ring-shaped form makes it impossible to give the furnace walls sufficient slope to enable repairs to be made in the same manner as in the open-hearth furnace. The difficulties with regard to cracking are due to the fact that the outer wall is ring-shaped, and has its highest temperature on the inside, whereas the equally ring-shaped inner wall is hottest outside. The only way of overcoming these difficulties is to use a material which neither contracts nor expands appreciably at very high temperatures. The lining used is made of very pure magnesite without any binding agent, and treated in a particular way. It possesses remarkable compactness, mechanical strength, and resistance to the action of slags. But even the best linings will not stand more than a few weeks if they are not further protected against the cutting action of ordinary slags. This difficulty the author claims to have solved by adding crushed magnesite in such a way that the slag can become saturated before it is able to attack the lining, an action which is much facilitated by the inclination and rotation of the bath. In this way it has even proved possible to make the inner wall grow by adding too much magnesia, and the lining of the furnace now has a life of from two to three months, a result which represents a considerable advance on industrial practice hitherto. The foregoing account does not do more than bring out the chief points of importance discussed at the meeting. In all nineteen papers were presented, several of them of distinct scientific value and interest, but time did not permit of their discussion.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

DR. M. BARTUZZI, president of the Italian Society for the Critical History of the Medical and Natural Sciences, has been appointed to the newly established chair of medical history in the University of Siena.

DR. CLIFTON F. HODGE, professor of biology at Clark University, Massachusetts, since 1902, has resigned that post, having accepted the offer of a chair in the same subject at the University of Oregon. In his new sphere Prof. Hodge will have special responsibilities in connection with a scheme of university extension lectures.

SIR RICKMAN J. GODLEE, Bart., president of the Royal College of Surgeons, London, has accepted an invitation to confer the fellowships of the American College of Surgeons at the first Convocation of that institution, which is to be held at Chicago on November 13 next. About 1400 prominent surgeons of the United States and Canada are to be created fellows.

DR. W. F. G. SWANN has resigned his position as assistant-lecturer and demonstrator of physics at the University of Sheffield in order to take up, on October 1, the post of physicist in charge of experimental work in the new laboratory at Washington of the department of terrestrial magnetism of the Carnegie Institution of Washington.

A COURSE of three lectures dealing with the early history of medicine has been arranged for delivery by the historical section of the Royal Society of Medicine. The first lecture will be given on October 10, by Prof. Jastrow, of the University of Pennsylvania, and will treat of Babylonian Medicine; the subsequent discourses will be delivered by Prof. Elliot Smith, F.R.S., on Egyptian medicine, and by Prof. R. Caton, on Greek medicine.

THE widow of Principal Caird has bequeathed to the University of Glasgow, in memory of her late husband's long connection with the University, the sum of 4000*l.* for the founding of two scholarships, to be known as "The Principal Caird Scholarships," to be awarded annually by examination to the student in the University who is most distinguished in either classics or mental philosophy, or both. The sum of 1000*l.* is also left to the Western Infirmary, Glasgow, and 500*l.* to the professor of moral philosophy of Glasgow University for books or prizes.

WE learn from *Science* that Dr. H. G. Leach, secretary of the American-Scandinavian Foundation (endowed by the late Mr. Niels Poulson with a gift of 600,000 dollars to maintain an interchange of students, teachers, and lecturers, and to promote in other ways intellectual relations between the United States and Scandinavia), has returned from an official tour in Sweden, Norway, and Denmark. Fellowships have been awarded to two representatives from each of the three countries referred to, and those selected will enter American universities in the autumn. Plans also have been discussed for an exchange of professors between the University of Copenhagen, the University of Christiania, the University of Upsala, and several American institutions.

THE Northampton Polytechnic Institute, Clerkenwell, London, E.C., has now issued its "Announcements" for the session 1913–14. The educational aim of the polytechnic is to provide classes in technological and trade subjects, special attention being directed to the immediate requirements of Clerkenwell. There are day and evening courses in mechanical and electrical engineering, in technical optics, and in horology. The engineering courses include sub-sections in automobile work, aëronautics, and radio-telegraphy. In addition, there are evening courses in electrochemistry, metallurgy, and domestic economy. We notice that during the past year the equipment has been extended. Amongst the more important items may be mentioned in the mechanical engineering department a Linde refrigerating plant, available for carbonic acid or for ammonia, and an outfit for the microphotographic examination of engineering materials. In the electrical engineering department the laboratory equipment for radio-telegraphy has been increased, and additions have been made to the equipment of generators, measuring instruments, and photometers. In the metallurgical department the equipment of electric and gas furnaces and pyrometers has been augmented. A new departure is being made in the section of telegraphy and telephony in the arrangement of special classes for workmen on the maintenance and constructional staff of the Post Office, and also for boy messengers. The latter classes are intended to meet the difficulty of the blind-alley occupation into which the Post Office plunges these boys, and the experiment, which is of public interest, will be watched sympathetically.

THE prospectus of university courses in the Municipal School of Technology, Manchester, for the session 1913–14, is now available. It will be remembered that university work in Manchester was coordinated in 1905 by the establishment of a faculty of technology in the University of Manchester, with the principal of the Municipal School as dean of the faculty and with the heads of the mechanical and electrical engineering, of the applied chemistry, and of the architecture departments of the school as professors of the University. The University courses provided by the School of Technology lead to the degrees of bachelor and master of technical science (B.Sc.Tech. and M.Sc.Tech.). These degrees may be taken in the following divisions of technology:—Mechanical engineering, electrical engineering, sanitary engineering, applied chemistry, mining, architecture, and textile industries. In addition, the school provides courses of post-graduate and specialised study and research, in numerous branches of technical science, for a fourth year, to students who have completed the three years' course for a degree or certificate successfully, or are otherwise deemed competent to enter upon them. The School of Technology has also published departmental prospectuses of the part-time evening courses, and the apprentices' day courses to be held at the school during the coming session. The number of evening students has reached the limit of the accommodation provided by the present building, but the demand for advanced courses continues to increase, and it has been found necessary to abandon the more elementary classes, and to raise the fees in other cases. A special feature is the large proportion which the advanced work bears to the whole. This evening work in the case of a number of courses is of the same standard as that given to third year students reading for an honours degree in a British University.

BOOKS RECEIVED.

Western Australia. Astrographic Catalogue 1900·0. Perth Section, Dec. −31° to −41°. From Photographs Taken and Measured at the Perth Observatory, under the direction of W E. Cooke. Vol. ii. Pp. 100. Vol. ii. Pp. 103. (Perth, Western Australia.)

The Romance of Scientific Discovery. By C. R. Gibson. Pp. 318+plates. (London: Seeley, Service and Co., Ltd.) 5*s*.

Researches in Magneto-optics. By Prof. P. Zeeman. Pp. xv+219+viii plates. (London: Macmillan and Co., Ltd.) 6*s*. net.

Encyclopaedia of the Philosophical Sciences. Vol. i., Logic. By A. Ruge, W. Windelband, J. Royce, L. Couturat, and others. Translated by B. Ethel Meyer. Pp. x+269. (London: Macmillan and Co., Ltd.) 7*s*. 6*d*. net.

Cotton Spinning. By W. S. Taggart. Vol. i. Fourth edition. Pp. xxxvi+262. Vol. ii. Fifth edition. Pp. xiv+245. (London: Macmillan and Co., Ltd.) 4*s*. net each vol.

A First Course in Projective Geometry. By E. H. Smart. Pp. xxiii+273. (London: Macmillan and Co., Ltd.) 7*s*. 6*d*.

The Catskill Water Supply of New York City. By L. White. Pp. xxxii+755. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd.) 25*s*. 6*d*. net.

The Improvement of Rivers. By B. F. Thomas and D. A. Watt. Second edition, re-written and enlarged. In two parts. Part i., pp. xiv+369+plates 1–45. Part ii., pp. ix+334–749+plates 45*a*–76. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd.) 2 vols., 31*s*. 6*d*. net.

A Treatise on Wooden Trestle Bridges and their Concrete Substitutes according to the Present Practice on American Railroads. By W. C. Foster. Fourth edition, revised and enlarged. Pp. xix+440+76 plates. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd.) 21*s*. net.

Weltsprache und Wissenschaft. Gedanken über die Einführung der internationalen Hilfsprache in die Wissenschaft. By Prof. L. Couturat, Prof. O. Jespersen, Prof. R. Lorenz, and others. Zweite Auflage. Pp. vi+154. (Jena: G. Fischer.) 2 marks.

Naturphilosophische Plaudereien. By H. Potonié. Pp. v+194. (Jena: G. Fischer.) 2 marks.

Egyptian Art. Studies by Sir Gaston Maspero. Translated by E. Lee. Pp. 223+plates. (London: T. Fisher Unwin.) 21*s*. net.

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