THURSDAY, AUGUST 8, 1889.

## *EMPIRICAL LOGIC.*

*The Principles of Empirical or Inductive Logic.* By John Venn, Sc.D., F.R.S., Fellow and Lecturer in the Moral Sciences, Gonville and Caius College, Cambridge. (London : Macmillan and Co., 1889.)

THOSE familiar with Dr. Venn's previous logical writings felt sure that his new contribution would at least be something very different from an ordinary text-book. There is a novelty, perhaps something of a quaint peculiarity, in the manner of viewing and illustrating his subject, which gives to the author's works an appearance of originality which might be easily confused with that which is due, as in the case of such a treatise as Mill's "Logic," to a radically new conception. And to say this in these days, when logical text-books are multiplied, and, as some would think, all the old problems have been finally threshed out, is no small praise. In the less frequently explored fields already traversed by Dr. Venn—the logic of probability and symbolic logic—there was, of course, more room for such fresh treatment. This freshness is, however, just as conspicuous in the new treatise, which goes over the well-trodden ground of common logic. If anybody is stupid enough to think that logic is necessarily a dry subject, he may be recommended to look into Dr. Venn's last treatise. It is brimfull of shrewd observation, of apt illustration taken from the least conventional sources ; more than this, it has humour, and it has fancy—a logician's, of course, but of a genuine quality.

In his general stand-point the author is, as the title of his book tells the expert, and as he fully discloses in his introductory chapter, not far from that of Mill. That is to say, he is an out-and-out materialist. Logic is not, as the formalist says, concerned only with the mind's thought and its normal forms, but occupies itself about the relation of this thought to objective fact or existence—that is, about objective truth. Hence here, as with Mill, we find the reference to reality running through the whole treatment of the subject. This emphasizing of the objective aspect is made sufficiently plain by the fact that, in his first chapter, before taking up the common topics, terms, propositions, &c., he deals at great length with the "physical foundations of inference," the assumptions with respect to the nature of the external world with which the logician sets out. In some directions, indeed, Dr. Venn carries this objective reference further than Mill, and with good results. Particularly valuable is the account of the meaning of reality or objective truth in the case of fictitious ideas, as "dragon." At the same time, our author is very far from making logic a purely objective science in the sense in which the physical sciences are objective. Having to give an account of and to provide rules for inference, it must at every step take into account the subjective aspect as well. Thus it has to consider facts so far as they are known, and, whilst it insists that names are representative of real things, it no less clearly contends that these names sum up and embody the amount of knowledge we happen to possess of the realities at any particular time. The steady grasp of this twofold aspect of the subject-matter of logic gives Dr. Venn a great advantage in the treatment of details. This is strikingly illustrated in his whole account of the connotation of names, and the related subject, definition. What a common name, *e.g.* "gold," means is of course a group of qualities known to exist in certain real things ; but a glance shows us that these are not all the qualities that exist in the things, but only a certain portion of these conventionally selected. So again, in dealing with hypothetical propositions, the author turns his recognition of the double aspect to good account. A hypothetical statement, of the form, "If the summer is hot, the supply of water will be diminished," has at once a reference to clear objective fact, and to the mind's doubt or ignorance. The mind's attitude of doubt is seen in the very form of the supposition, "*If* the summer is hot," the objective certainty reveals itself in the inference confidently drawn from the supposition. One may add that it is this same just recognition of the equal rights of subject and object in logic which accounts for his taking a more modest view of induction than Mill. He tells us in his preface that the title "Empirical Logic" is intended to show that "no ultimate objective certainty, such as Mill, for instance, seemed to attribute to the results of induction, is attainable by any exercise of the human reason." Mill's confident repose on a system of universal law has been rudely handled by writers like the late Prof. Green, who denied his right to reach such universality on his purely empirical or Humean basis. And now we have scientific men like the late Profs. Clifford and Jevons, and Dr. Venn, urging from Mill's own empirical stand-point that experience can never guarantee such perfect universality.

In the case of a work like the present one it is difficult for the reviewer to give, by means of a few typical references, the scope and gist of the argument. As already hinted, it is not in any sense a new logical system. Indeed, it can hardly be called a complete system at all. It does not take us in an orderly, systematic manner through all the well-recognized divisions of the subject. Thus a large part of the domain of the common syllogistic logic is very slightly dealt with, if at all ; no reference being made to the so-called laws of thought, or the axioms which underlie the thinking process so far as this is merely self-consistent. Nor even if we view it as a treatise on inductive logic can Dr. Venn's work be called complete, since some of the most important matters appertaining to induction—for example, experiment in relation to observation, the deductive method, scientific hypothesis—are altogether passed by, or only just referred to. In fact, Dr. Venn's volume, which he tells us embodies the substance of courses of lectures, must be regarded as a series of discussions of some of the more important or more neglected points of logic, having a certain connection from the fact that they imply one *manière de voir*, and the same fundamental principles. This being so, one must try to indicate the quality of the work by a reference to one or two of the more important matters dealt with.

To begin with the first chapter, which is an excellent compact statement of the main pre-suppositions of material logic, Dr. Venn has done good service in showing how much work of the mind has gone to the construction of the world of objects with which the logician sets out. All that he says here about the work of analysis and synthesis might perhaps be translated by a Kantian or even a Hegelian into his own philosophical dialect. What our author, however, is concerned to bring out is the practical motive that underlies our common thought-distinctions. He shows in a striking manner that there is something arbitrary in our way of demarcating "things" or "objects," though this is justified by practical exigencies. The recognition of this elasticity in our conception of a thing enables the writer later on to handle with good effect the common distinction between concrete and abstract terms. These, says our author, are not absolute, but relative designations. "Hardly any object, as objects are regarded by us, can be selected, which is not to some extent a product of our powers of abstraction, and the more or less of this faculty called into play in any particular case hardly warrants us in labelling the instances respectively with such distinct designations."

Somewhat similar considerations are applied to collective terms. "There is nothing," writes Dr. Venn in his most ingenious vein, "to hinder us from taking a 'scratch lot' of things, to use the slang phrase, and giving a name to the lot with the caprice which we show in naming a yacht or a dog," *e.g.* the persons who happen at a particular moment to be in a given space in Fleet Street. This idea of the arbitrary limits of our common distinctions is made good use of in the treatment of the relation of the subject and predicate in propositions where, as too rarely happens in English works on logic, adequate recognition is taken of impersonal propositions. With reference to this last topic, however, it should be said that Dr. Venn's treatment, though fresh and suggestive, is hardly adequate. He seems to start from the supposition that logicians resolve all forms of predication into attribution of qualities to things (the subjects). This is to ignore the careful analysis of the import of propositions carried out by Mill, Bain, and others.

In a work on inductive logic the mode of dealing with causation may be said to be conclusive as to the writer's competence. Dr. Venn's account forms one of the most valuable portions of his work. Very happy and fruitful in simplification and the dispelling of confusion is his idea that the logician in dealing with the relation of cause and effect stands midway between the point of view of every-day practical sense and that of a rigorously scientific or speculative intelligence. The popular view is practical, and is subordinated to the production of (desirable) effects. The logician improves on this, first of all by enumerating the antecedents more completely, and secondly by "screwing up the cause and effect into close juxtaposition,"—that is, into an approximately immediate sequence. At the same time, he does not aim at absolute completeness in either respect, for this, as the writer shows, would be to defeat his end. He retains something of the popular practicality of view, and this is ingeniously illustrated in the common logical doctrine that, whereas the same antecedent can only be followed by one consequent, the same consequent can be preceded by different antecedents (plurality of causes). Perhaps Dr. Venn is a little hard on Mill and logicians generally for their way of formulating the causal relation. No doubt, as he contends, every concrete event is a highly complex group of elements, followed by another complex group. But the logician is dealing with causation for purposes of induction. He assumes that the investigator must generalize, and generalize as far possible, if he wishes to attain his goal, viz. comprehensive principles or laws. A general statement, such as "Friction produces heat," is, no doubt, in a sense highly elliptical. There must of course be, in every case, a definite set of circumstances in which the friction acts and the heat is developed. But there is no need to refer to these in stating the general truth; on the contrary, this statement, just because it is a large principle available for guidance in a vast number of diverse cases, must be an abstraction. Historically considered, moreover, it may be said that Dr. Venn makes too much of the practical impulse in the genesis of our idea of causation. Primitive man, as soon as he could form an idea about cause at all, was presumably already beginning to ask about the origin of things, and to work out a crude cosmogony of his own.

On the nature of inductive processes, and the well-known methods formulated by Mill, our author is distinctly in advance of his predecessors. With his customary caution he points out the difficulties that have to be got over before generalization can begin. Combining in a manner the views of Mill, Whewell, and Jevons, he regards a complete process of inductive discovery as consisting of three steps, viz. (1) a stroke of insight or creative genius in order to detect the property to be generalized (and possibly also the class); (2) the formal process of generalization; and (3) the final stage of verification (apparently by way of deduction). The chapter on the methods is judiciously critical, and may with advantage be compared with Mr. Bradley's less discriminating treatment. The way is prepared for a study of the complex problems of physical induction by the selection of a simple artificial example, viz. the case of a man in an hotel office, who has to determine what room rings a particular bell. This case is dealt with by purely formal considerations, similar to those which guide us in the problems of symbolic logic. It is then shown that such purely formal treatment is inappropriate in the case of physical investigations, and the special methods of induction are thus introduced as a *pis aller*. The author is most original in dealing with the Joint Method, which every careful reader of Mill's "Logic" must have felt was very far from clear.

There are other features in Dr. Venn's scheme of induction which deserve careful notice. Among these may be named the account of co-existences as distinguished from sequences (chapter iii.); the description of the nature and function of units and standards (chapters xviii. and xix.), which is less technical and more suitable to a logical treatise than that given by Jevons; the highly characteristic chapter on the possible extension of our general powers of observation (chapter xxiii.), where the bold idea is entertained of our being able some day to spread out an event in time just as the telescope and the microscope enable us to spread out an object in space; and, lastly, the discussion in the concluding chapter of the effect of our practical tendencies in modifying a strictly logical or speculative view of the world.

Any one of these might well call for detailed remark if space permitted. They show the author at his best, finely observant of overlooked points, subtly ingenious in devising new, quaint, and even startling possibilities. But the reader must be referred to the volume itself for a fuller appreciation of these qualities.

When one has gained much pleasure and profit from a work, it seems almost shabby to begin to find fault. Yet no critical reader of Dr. Venn's treatise can fail to perceive its defects. It is as if the author had boldly set them before our very eyes challenging criticism. The want of close connection has already been touched on. There seems, indeed, a surprising lack of systematic arrangement, as if the author had sat down to write without a clear plan before him. Poor formal logic gets badly treated. Thus we have an acco unt of terms, propositions, including hypotheticals and disjunctives, but no account of the syllogism. Nor can it be said that the writer has introduced just as much of the common syllogistic logic as is needed for setting forth the processes of induction. Much given us under terms and propositions cannot well be regarded as needed in a treatise on the logic of induction. Sometimes, indeed, the author wanders into the mystic region of symbolic logic. Again and again he opens up in a tantalizing way views which he does not stop to establish. One may instance the point touched on (p. 43), whether the converse of a particular proposition is in substance a new proposition. This depends on our view of the import of a proposition, which, as already pointed out, is not adequately dealt with. Again, the author seems to deny the existence of a negative disjunctive of the type "Either A is not B or C is not D," but he does not trouble to prove the point, or indeed to make clear what he precisely means. It is surprising, again, to find Dr. Venn discussing the functions of the syllogism not only without giving any preliminary sketch of it, but without the barest reference to the nature of the axiom which underlies it. On the other hand, a good deal that is known to the general student from previous works (including the author's own) is needlessly repeated, and helps sadly to swell the size of the volume. Another feature that will strike every careful reader, and which is strongly suggestive of defective plan, is the frequency of the forward reference, as "we shall see by and by," and so forth. This is apt to be very confusing. In noting this, together with the comparative infrequency of the backward reference, one cannot help thinking of the author's remark on the popular view of causation, that it looks forward rather than backward.

A number of the author's statements seem to the present writer open to dispute. It must be surely a slip which makes him write of the classifications of natural history as made up of *collective* terms (p. 170). The Dicotyledons are surely not a collection in the sense in which the House of Commons is a collection. The limitation of the denotation of terms to present existences (p. 179) strikes one not only as highly capricious, but as inconsistent with what is said about differences of time in connection with predication. Once more, one would like to challenge the strong statement that the only easily discoverable instance of a purely verbal dispute is that about the "sameness" of a thing (p. 296). In one place, at least, the writer's ingenuity seems to carry him too far. Writing of logical definition by genus and differentia (p. 302, by a slip written genus and species), Dr. Venn tries to show that this is perfectly rational on the supposition (which logic is bound to make) that we all know the meaning of our terms, or, since the very need of defining a term shows that there is one term of which this cannot be supposed, of all terms but one. But it is obvious that this consideration would equally suggest or justify an inverse process of definition, viz. by naming a lower species, and subducting its differentia. Such slight blemishes as these are probably inseparable from Dr. Venn's manner of work, and it can safely be said that they detract but little from the general and lasting impression of masterful competence which his volume is certain to leave on the student's mind.

JAMES SULLY.

---

## REMSEN'S "INORGANIC CHEMISTRY."

*Inorganic Chemistry.* By Ira Remsen, Professor of Chemistry in the Johns Hopkins University. (London: Macmillan and Co., 1889.)

THIS book is of interest from the circumstance that it is the first of its kind in the language of any pretensions which is based upon the periodic law. It is further characterized by the fulness with which general relations are discussed. The attempt is made to present the facts of inorganic chemistry in such a manner as to bring out their analogies and connections, with a view of elucidating the broad general principles of the science. Details of experiments, either as showing the origin and modes of preparation of products, or as illustrating their leading properties, are for the most part omitted, or are relegated to an appendix containing special directions for laboratory work. The book is put together in a plain, straightforward manner, with no attempt at any literary airs and graces; indeed, we may add that at times the style verges on a simplicity which is perilously near being puerile. Having said this much in commendation of the general plan of the work, we have said all we can say in its praise. For, however excellent may be the plan of a treatise of chemistry, its main value, after all, must depend upon the accuracy and completeness of its statements; and, as we proceed to show, there is much in this book which is both inaccurate and incomplete. From the style in which it is issued, and its price, we presume that the work is intended for the benefit of comparatively advanced students—at all events for a higher grade than that for which the author's well-known smaller books were prepared. Indeed, we are distinctly informed that the earlier works were intended to form a series of which the present volume is the most advanced member. Now, whilst it may be convenient for the purpose of elementary teaching not to tell the whole of what is known about a thing, the advanced student, if he has any scientific instinct at all, insists on knowing the truth, the whole truth, and nothing but the truth. Unfortunately, he does not always get that from this work. Prof. Remsen is admirable in his introductory books. In these there is a reticence of statement and a subordination of facts which make the books excellent for the purposes of school-teaching. But in the larger book it appears to us that the author suffers from the defects of his excellencies: what is a merit in the "Briefer Courses" becomes a positive blemish in the advanced work. Indeed, the volume before us seems to be nothing but the smaller work on inorganic chemistry "writ large," since in point of knowledge the student is not carried very much further than he is in that book. Take, for example, the statement respecting the mode of preparing hydrogen, given on pp. 26 and 27. We read that, when sulphuric acid acts upon zinc, the chemical change is represented both qualitatively and quantitatively by the equation $Zn + H_2SO_4 = ZnSO_4 + 2H$. This is stated without a word of qualification, in a long paragraph on the complex nature of the changes which take place in a chemical reaction; and yet every teacher knows that this equation does not express the truth, the whole truth, and nothing but the truth about the matter. Again, too, on p. 30, in the account of the mode of preparing oxygen, we have the conventional methods of representing the decomposition of potassium chlorate into equal parts of perchlorate and chloride, and the subsequent decomposition of the perchlorate into chloride, whereas Teed, and, subsequently, Frankland and Dingwall, showed some years ago that these equations altogether fail to represent what actually occurs.

McLeod's work on the part played by the admixed manganese dioxide in facilitating the evolution of oxygen from potassium chlorate is perhaps too recent to have received notice in the very meagre account given of the supposed modes of action of this substance; but the space occupied by the description of "gnomium," which is still more recent, might, we think, have been more profitably employed by some mention of Mercer's theory of "catalysis." This poverty of statement is, at times, almost exasperating. The account of Lavoisier's work, on p. 5, would have seriously jeopardized the chances of a London University matriculant if given in an examination paper. Nine out of ten average students would gather from this account that Lavoisier made chemistry what it is to-day by proving why it was that, "whenever water is boiled for a time in a glass vessel, a deposit of earthy matter is formed." With respect to the etymology of the term oxygen, it is stated that "the name is at present somewhat misleading," which might imply that it may possibly become less so in the future. On p. 298 we are told that "it was in an examination of urine for the purpose of discovering the philosopher's stone that phosphorus was first discovered in 1669." On p. 383 it is stated that "the name soda-water had its origin in the fact that the carbon dioxide used in charging the water is frequently made from primary or acid sodium carbonate." Are we to infer also that lithia and potash waters are prepared from carbonic acid evolved from the carbonate of the respective metals? On p. 141 we read that Lavoisier "considered chlorine to be an oxygen compound of some undiscovered element which was called *murium*. . . . The acid was accordingly called *muriatic acid*. . . ." If this implies that the term "muriatic acid" was derived from *murium*, it is contrary to Lavoisier's own account of the origin of the name. On pp. 60 and 61 of his "Traité Élémentaire de Chimie," partie 1, chap. iii. ("Œuvres de Lavoisier," Imprimerie Impériale), "De la Nomenclature des Acides en général, et particulièrement de ceux tirés du salpètre et du sel marin," he says:—

"Rien ne nous a été plus facile que de corriger et de modifier l'ancien langage à l'égard de ces acides; nous avons converti le nom d'acide vitriolique en celui d'acide sulphurique, et celui d'air fixe en celui d'acide carbonique; mais il ne nous a pas été possible de suivre le même plan à l'égard des acides dont la base nous était inconnue. Nous nous sommes trouvés alors forcés de prendre une marche inverse, et, au lieu de conclure le nom de l'acide de celui de la base, nous avons nommé, au contraire, la base d'après la dénomination de l'acide. C'est ce qui nous est arrivé pour l'acide qu'on retire du sel marin ou sel de cuisine. . . . Nous avons nommé cette base inconnue *base muriatique*, *radical muriatique*, en empruntant ce nom, à l'exemple de M. Bergman et de M. de Morveau, du mot latin *muria*, donné anciennement au sel marin."

And in the index it is given: "*Acide muriatique*—son nom dérivé du mot latin *muria*, 61." As a matter of fact, the term was employed by Bergman and Scheele some years before the Lavoisieran nomenclature was published.

Loose, imperfect, or partial statements are, in fact, to be found on every other page. The word *eudiometer* is derived from εὔδια, calm air, and μετρον, a measure, "because it is used for the purpose of measuring gases (p. 51)." On p. 61, dissociation is defined to be "the gradual decomposition of a chemical compound by heat." Contrary to the statement on p. 44, hydrogen has *not* been liquefied. If this gas does not unite with oxygen at ordinary temperatures (p. 45), how is the action of platinum foil and of the Döbereiner lamp explained? The well-known process of extracting silver from argentiferous lead is called *Pattison's* method (p. 598). On p. 304 it is stated that phosphine unites with hydrochloric acid to form phosphonium chloride, and the statement is made that the reaction is perfectly analogous to that which takes place between hydrochloric acid and ammonia. It is nothing of the kind: phosphine and hydrochloric acid only combine under pressure, and the compound is dissociated, at ordinary temperatures, when the pressure is released. To judge from the statement on p. 281, the author is ignorant of the work of Tilden on the oxychlorides of nitrogen. The rusting of iron (p. 693) is *not* due to moisture in the air: iron does not rust in moist air in the absence of carbonic acid, as every tin-plate worker knows, and as Crace-Calvert, years ago, conclusively demonstrated. On p. 121 we have an account of chlorine trioxide, although Garzarolli-Thurnlackh, more than eight years since, working under Pebal's direction, showed that the substance so designated is a mixture of the dioxide with varying quantities of free chlorine and oxygen. The author still believes, apparently, in the existence of the ammonium-amalgam, and wholly ignores the work which shows that it is nothing but a metallic froth. He incorrectly describes the action of sulphuric acid upon potassium permanganate (p. 683), and tells us that no oxygen compound of fluorine is known, in spite of the existence of an oxyfluoride of phosphorus. The argument as to the valency of fluorine and the constitution of fluosilicic acid (p. 416), based on the supposition that hydrofluoric acid has the molecular formula $H_2F_2$, falls to the ground in view of the recent work of Thorpe and Hambly. These by no means exhaust all the errors we had noted, but the list is sufficiently long to show that the book has apparently been hastily and somewhat carelessly put together. It has, however, certain good points, and by a judicious overhauling might be made into a good book, for it is precisely one of those works that would have been better if the author had taken more pains.

## THE MIDDLE LIAS OF NORTHAMPTONSHIRE.

*The Middle Lias of Northamptonshire.* By Beeby Thompson, F.G.S., F.C.S. Pp. 150. (London: Simpkin, Marshall, and Co., 1889.)

THE sub-title of this work explains that the subject is considered stratigraphically, palæontologically, economically, as a source of water supply, and as a mitigator of floods.

The author commences with some account of the beds grouped as Middle Lias, there being considerable difference in the classifications adopted by geologists, from the fact that the distinction between Middle and Lower Lias is mainly dependent on fossils. In considering this matter we have to deal with a series of clays, exhibiting a succession of organic remains, intimately connected, and yet characterized at different horizons by certain species of Ammonites. There are no stratigraphical planes of demarcation for our guidance, and it is merely a matter of convenience (or inconvenience as the case may be) to adopt a divisional line. The subject was discussed at some length in NATURE (vol. xv. p. 113) and we may therefore pass on to say that Mr. Thompson includes in his Middle Lias the zones of *Ammonites margaritatus* and *A. spinatus*, in this respect following the plan adopted by the Geological Survey.

As with the junction of the Middle and Lower Lias, so with that of the Middle and Upper Lias, there is, at any rate in Northamptonshire, evidence of intimate connection. We find, in fact, a "transition bed" between Middle and Upper Lias; and this, although but a few inches thick, has furnished a large number of fossils to Mr. T. Beesley, Mr. E. A. Walford, and the author of this work. Much interest attaches to this transition bed, from the fact that it contains an admixture of Middle and Upper Lias fossils, although a larger proportion of the former. Among the Upper Lias Ammonites found in it are *A. communis*, *A. annulatus*, and *A. Holandrei*; and it is noteworthy that *A. communis* and *A. crassus* are recorded also from the Marlstone below (zone of *A. spinatus*). All these species are very closely connected, and the abundance of *A. communis* in the lower beds of the Upper Lias of some parts of England, serves to show that its value as a zonal species in the uppermost beds is very local. We note that Mr. Thompson speaks of "falcifer" Ammonites—a mode of expression with which we fully sympathize, for the species, unfortunately, are becoming so much subdivided that before long no one but a specialist in Ammonites will dare to identify any particular form.

The work before us well illustrates the progress made in our knowledge of the details of British formations. The author has evidently laboured long and earnestly at his subject, and indeed no one but a resident geologist could have given us such particulars of the subdivisions of the Middle Lias and the fossils that occur in the different layers, for some sections yielding valuable information are open but for a short time, and the geologist who spends but a few weeks in a district may fail to find exposures of every zone. Moreover, now increasing attention is given to the biological history of species, the precise position they occupy in the series of strata is of the greatest importance. Hence the work is of value not merely from a local point of view, but as contributing much material that will help towards a full knowledge of the Lias of Britain.

Summarizing his results, Mr. Thompson catalogues 94 genera and 273 species from the Middle Lias, including, however, but few of the Foraminifera. Vertebrate remains are scarce, but the conditions of deposit, as remarked by the author, were to a large extent shallow water and littoral marine—conditions that appear to be generally unfavourable to the preservation of the fishes and reptiles of the Lias.

The economic products of the Middle Lias are duly noted by the author. These are practically confined to building-stone and brick earth. The valuable iron ores found in some localities hardly come into the area, although some beds were at one time worked at King's Sutton.

Considerable attention has been given by the author to the question of water-supply, and in 1881 he suggested that the supply for the town of Northampton might be increased by the formation of a number of dumb-wells. In this way he anticipated that the surface drainage might be conducted underground through the Upper Lias, so that the porous beds of the Middle Lias would be utilized as a natural reservoir, while at the same time the liability to floods would be lessened. The scheme was brought before the Town Council, but, as the author candidly admits, the Water Committee, after consulting Sir Robert Rawlinson, were fully justified in rejecting it. It is, however, far from apparent that the scheme was faulty in theory. The natural storage of water has been advocated by several authorities, and it has been put into practice in India. The whole subject is worthy of close attention, and we can commend this portion of Mr. Thompson's book to those interested in the questions of water-supply and drainage. H. B. W.

## OUR BOOK SHELF.

*A Dictionary of Explosives.* By Major J. P. Cundill, R.A. Published by the Royal Engineers Institute. (Chatham: Mackay and Co., 1889.)

IT is impossible to look at this list of explosive substances prepared by Major Cundill without coming to the conclusion that the chemist has had little to do with the most of them. Mixtures are things which do not delight the chemical mind either in an explosive substance or anything else. It places too much reliance on some mechanical operation, mixing or something of that kind, to give the chemical notion of exactness in its composition.

A theoretically perfect explosive would be a substance like hexanitro-benzene, $C_6(NO_2)_6$, but this has not yet been made. The variety and curious nature of substances and mixtures, many of them solemnly patented, described in this book, are most interesting. One, amongst several, is a mixture of carbonate of lime, chloride of sodium, and urine evaporated with charcoal. It seems pretty harmless as an explosive. Not so, however, many other mixtures containing potassium chlorate for which safety is claimed. It is really quite incomprehensible how people with the slightest knowledge of chemistry can propose mixtures containing potassium chlorate and organic substances, and in many cases even sulphur as well.

By drawing the attention of chemists to the amount of nonsense palmed off on the Patent Office, this little book will se ve a good turn; but it is also of practical value, as extracts from the specifications are given in many cases which may save much seeking.

Some advice at the end of the book is useful, especially to those interested in explosives in a professional way, but who are not sufficiently chemists to be able to deduce it for themselves. Possibly it is the fault of the specifications, and not the author, that benzene is written in several ways, benzole, benzine, &c.

On p. 68 there is an equation to represent the products of gun-cotton when detonated, to which perhaps some exception may be taken, but after all but slightly, for there is still much ignorance on the matter. It is

$$2C_6H_7O_23NO_3 = 9CO + 3CO_2 + 7H_2O + N_6.$$

It is very doubtful indeed whether any of these nitrates can be burnt under any conditions without yielding a considerable quantity of oxides of nitrogen as end products; probably NO in the first instance, which takes up oxygen from the air, and is undoubtedly the greatest drawback in the use of gun-cotton, glycerol nitrate, and similar substances.

Some advice is given about nitro-glycerine on p. 39. "Any indication of acid fumes or tinge of green should be followed by their prompt destruction with suitable precautions." It would have been well here to give some precautions even at the risk of repetition, for it is not safe to play with nitro-glycerine when in this state. The author might have added that an addition of aniline at this stage renders the destructive operations much safer.

Under the heading of smokeless and "noiseless" gunpowder, little more could be said at the present time than the author has ventured upon. We do not quite believe that a "noiseless" explosive will be so easily found as a smokeless one. Such a substance belongs almost to the category of explosives that act in "one direction only," or have no recoil.

We think the book will be useful in several ways. Blank pages are inserted for further additions to our stock of explosives, safe and unsafe, as they are published.

W. R. H.

*Gaseous Fuel.* By B. H. Thwaite. (London: Whittaker and Co., 1889)

THIS little book of forty-six pages contains the substance of a popular lecture delivered by the author, under the auspices of the Manchester and Salford Noxious Vapours Abatement Association. It gives an account of the principles which underlie the economical consumption of fuel in general, and of the various forms of "gaseous fuel" in particular, and more especially of those forms in which the lecturer is professionally interested. The book, of course, makes no pretensions to deal with the subject exhaustively: its main object, apparently, is to direct attention to the advantages of smokeless fuel as compared with coal as ordinarily burnt. The author is occasionally to be found tripping in his chemistry and physics, and there are, now and then, a few awkward turns of expression. Thus, we read that fire-damp "is a light carburetted hydrogen, one of the gaseous paraffines or methane, its principal formula being chiefly $CH_4$"! (p. 15). The inventor of the well-known laboratory burner is styled "Baron Bunsen." On p. 34 we read: "The principle of the development of motive power by the instantaneous combustion of gaseous fuel rests in the laws of Charles Gay Lussac and Boyle—*ergo*, that the pressure exerted by a gas varies directly as its volume." The author seems to imply that the idea of using the fire-damp at Hebburn Colliery, near Newcastle, originated in a suggestion made by him some two years ago in *Engineering*. In reality, the idea is due to the younger Buddle. Indeed, as a matter of fact, blowers which have been encountered in the process of working have been frequently utilized either for heating or illuminating purposes; notable examples are at Llwynypia and at Pandy, in the Rhondda Valley.

*A Treatise on Spherical Trigonometry, and its Application to Geodesy and Astronomy.* With Numerous Examples. By Dr. J. Casey, F.R.S. (London: Longmans, 1889.)

THIS is a sequel to the large "Plane Trigonometry" by the same writer, and is naturally drawn up on the same plan. Its size is handy, and yet it contains a very large amount of matter. Much of this the author claims to be original, and a great deal, as in the case of the "Plane Trigonometry," has been collected from the foreign mathematical journals. The first three chapters cover familiar ground, with here and there a new feature inserted. Chapter iv., entitled "Various Applications," gives properties of transversals, of isotomic and isogonal conjugates, of the Lemoine and symmedian points, and of some other lines with which recent plane geometry has made us familiar—more especially our author's own "Sequel to Euclid." Chapter v. discusses the spherical excess, and in chapter vi. we have a full account of small circles on the sphere. The subject of inversions is discussed in chapter vii., and in chapter viii. we have full details of the polyhedra. The last chapter gives an account of numerous applications of the subject, as to geodesy and astronomy. It would be almost impossible, we should say, to light upon a theorem elsewhere which is not contained here. More than 500 exercises afford scope for practice. As in the case of the "Plane Trigonometry," the author's great indebtedness to Prof. Neuberg, of Liége, is suitably acknowledged, for it is through this gentleman's courtesy the book is brought so thoroughly into touch with Continental sources of information.

## LETTERS TO THE EDITOR.

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

### Coronæ round a Light produced by a Peculiar St ucture in the Eye.

FOR some years past I have been aware that a bright light on a dark background appeared to be surrounded by faint coloured rings, and that these rings were due to something in the eye itself. But I gave them little attention, for I imagined they were formed in the same way as the coronæ seen when the sun or moon is covered by a thin cloud; opaque particles in the cornea, or little elevations or depressions of its surface, playing the part of the drops of water in the cloud. This is the view taken in Verdet's great work on the wave-theory of light. "Les cercles irisés, qu'à la suite de certaines infl mmations de la conjonctive on aperçoit autour des corps lumineux, se rattachent à la même cause que les couronnes; ces apparences sont dues à l'existence de granulations trè -petites et sensiblement égales dans la portion de la conjonctive qui se trouve en avant de la cornée transparente" (Verdet, "Leç ns d'Optique Physique," § 79). I have lately discovered, however, that the phenomenon in my own case must be due to quite a different cause.

A leading characteristic of the diffraction phenomena produced by a number of equal obstacles, *irregularly spaced*, is the bright disk surrounding the light, which is for the most part nearly white. Near the light it is bluish, while the outer bord r passes through yellow to red. To the red succeeds purple, blue, green, yellow, red, &c., the colours resembling those of Newton's rings. The central disk is far the brightest part, and there is no real break in the colours, though the first purple is a good deal darker than its neighbours. The easiest way to see these colours is to sprinkle a slip of glass with Lycopodium seed and look through it at a bright point of light. The above description applies equally well whether the obstacles are spherical or cylindrical. The latter form is nearly approached in Nature by the fine needles of ice of which many clouds must be largely composed. With other forms of obstacle the colours would be more or less blurred, but in any case the bright central disk would survive.

When recently engaged in investigating such phenomena, I noticed that the rings formed in my eye were of an utterly different character. There are two narrow rings, apparently in contact—the inner green, the outer red; the apparent breadth of each being about 20′, and the radius of the intermediate circle about 2° 30′. Within the green ring is a broad dark space, and then comes the ordinary colourless haze surrounding the light. The rings are not quite continuous, and certain short arcs are much brighter than the rest. But the arrangement of these arcs seems quite irregular, and is different in the two eyes. With this exception the two eyes behave alike. The green and red, though faint, are of good quality, not unlike a very faint prismatic spectrum. They are rather capricious in their appearance, requiring a dark background and a moderately bright light. A small arc light some thirty yards from my window generally shows them well, though they vary a good deal in brightness, and at times I cannot see them at all.

The question was, how the colours were produced. After pondering the matter for some time, and rejecting one explanation after another, the true solution suddenly flashed upon me. The colours are the first spectrum of a diffraction grating, and the ring form is due to the bars of the grating lying in different directions in different parts of the eye. The idea was readily put to the test. Cutting a small hole, one-tenth of an inch square, in a piece of paper, I held it in front of the eye. When the aperture was in the centre, the coloured rings vanished; when it was drawn to one side to the very edge of the pupil, two bright spots appeared on the circle, one above, the other below the light. The rest of the circle was invisible. As the aperture was moved round the outside of the pupil, the two bright spots revolved round the circle, preserving their angular distance of 90° from the aperture. This shows that the bars of the grating radiate from the centre of the pupil and are only found near its edge. From the dimensions of the rings we may deduce that the lines are spaced at the rate of about 75 to the millimetre, or 1900 to the inch. Since the coloured ring is not uniformly bright, the grating must be imperfectly developed behind some parts of the outer edge of the pupil. But trial with the diaphragm left no doubt that the structure was present to some extent all round. I then compared the coloured rings with the spectra seen on looking at a light through an ordinary diffraction grating of 3000 lines to the inch. The appearance was very similar, though in the latter case of course the red and green were much brighter, and were accompanied by a comparatively faint violet band. The breadth of the red and green bands relatively to their distance from the light agreed very well with the measurements given above.

Another evening I prepared some diaphragms with annular apertures of which three, A, B, C, had the inner and outer diameters respectively 10·7 and 8·6 mm., 9·9 and 7·6 mm., 8·1 and 6·1 mm. In A the central stop was large enough to hide the light and of course extinguish the rings too. With B when held centrically the rings were very plain—indeed yellow could be made out between the green and red—while the light was distorted and enlarged by both spherical and chromatic aberration. With C the rings were visible but not distinct. I found too that with B I could see the rings round the naked flame of a bright paraffin lamp only two or three feet away, for the pupil enlarged till it cleared the stop. But with C, I had to move two or three yards away before the rings appeared. These experiments show the diffracting structure to exist in a ring, whose diameter lies between 8·1 mm. and 7·6 mm., and that it does not extend far inside the lower limit. Further, the diameter of the pupil when the rings are visible may be decidedly less than 8·6 mm. The structure is not on the inner edge of the iris, but it may lie either in the cornea or in the crystalline lens. The latter is known to be built up of closely-packed radial fibres from 0·0056 mm. to 0·0112 mm. in breadth (Helmholtz, "Physiologische Optik," § 5). It seems probable that some modification of these near the edge of the lens form the diffracting layer. I have since found that at a distance of a hundred yards from the electric light the pupil can be made to clear the central stop of A. There is then seen a narrow circle of light, too faint to show colour. I was not able to get a good enough measure of its diameter to decide whether it was smaller than before.

I can hardly fancy this curious structure in the eye to be a rare peculiarity. One of my friends saw the green ring well defined round the electric light one evening, and with practically the same radius as I. He was not sure about the red. Inside the green he described the colour as very dark purple, almost black. Probably this was a contrast effect, but possibly it was the violet of the spectrum. In Sir John Herschel's "Meteorology" I find the following passage. After speaking of coronæ round the sun, he says: "Occasionally the cornea of the eye itself becomes filmy by the diffusion over it of minute particles, which (such at least is our personal experience) exhibit round a candle two or three beautiful coronas, the second of 17° 57′ in diameter, of vivid colours and most perfect definition." This description makes me feel suspicious that the rings were of the same class as mine. It suggests separate spectra such as are produced by a diffraction grating. Further, the accuracy of the measurement implies a tolerably narrow ring, whereas in ordinary coronæ, if the second green had a diameter 18°, the second blue and second red would have diameters 15° and 23° respectively. His dimensions do not agree with mine, but imply bars or lines at distances of about 0·007 mm. Fibres of this breadth are found in the crystalline lens. JAMES C. McCONNEL.

Davos, Switzerland.

## Use or Abuse of Empirical Formulæ, and of Differentiation, by Chemists.

As I believe that I am one of the "ingenious and clear-sighted" chemists who, Prof. Lodge suggests, may be "run away with by a smattering of quasi-mathematics and an over-pressing of empirical formulæ," I hasten to assure him that he is quite wrong in his surmises.

With every word of Prof. Lodge's remarks on the proper method of examining curves I heartily agree; with his strictures on the abuse of formulæ I more than agree: I should advise chemists not even to use them.

The method of examining the continuity of any curve by plotting out the experiments themselves, and then differentiating the curves representing them, is the method which I have applied in nearly every case, and applied it, I believe, for the first time to questions of a chemical nature. The only difference between my *modus operandi* and that which Prof. Lodge suggests is that, instead of differentiating the curves by a mechanical integrator, I take readings from them at definite intervals, and find the differences between these readings arithmetically.

I do not consider, however, that this is the safest method of examining results. The method which was introduced to the notice of chemists by Mendeleeff, which was used subsequently by Crompton, and on which I have placed my chief reliance, consists of differentiating the experimental numbers themselves, and not the curves which may be drawn to represent them. If $s_1$ and $s_2$ be the densities of $p_1$ and $p_2$ per cent. solutions, $\frac{dp}{ds}$ at a percentage $\frac{p_1 + p_2}{2}$ is given by $\frac{s_1 - s_2}{p_1 - p_2}$.

Each of these two methods has its own special advantages, but the balance is generally strongly in favour of the last one. It does not necessitate the drawing of the original curve, which drawing may often be considerably modified by the "taste" of the drawer; it will sometimes bring about the recognition of breaks which might be overlooked in the original curve, for though the differential curve can show no breaks which do not exist in the original curve, it may often, as a consequence of its very nature, show breaks clearly, which would be recognized only with difficulty in the original curve; and, lastly, the proper depiction of the original curve is often a practical impossibility, as, for instance, with the densities of sulphuric acid solutions, where the scale which would have to be adopted to give the experimental error a fairly visible magnitude would involve dealing with a curve some 3000 inches long.

Prof. Lodge could, no doubt, have told us more than he has done of the difficulties and dangers of differentiation in any form, and, perhaps, the extensive practical experience which I have had in the process has made me more alive to these dangers than even he is. I need only say here that I have not yet come across a case where I should feel warranted in stating that a break existed on the evidence of one curve only where the break depended on differentiation for being clearly visible. In my own work I have never considered any breaks as being more than "suggested" unless they were shown by at least two different properties of the substance under examination; the majority of the breaks which I insist on are shown by more than two, in some cases by as many as seven different properties.

As to the examination of the curves by means of empirical formulæ, nothing of the sort has been done, and it is difficult to understand how Prof. Lodge, even though he speaks under correction, should have so misunderstood the methods adopted. If Mendeleeff's paper may have been open to misinterpretation, Crompton's certainly was not, for he gives in a tabular form the results of the direct differentiation of the experimental numbers themselves; an abstract only of my own paper has as yet appeared, and I have not got it by me to refer to, but I do not think that the terms "formula" or "equation" occurred throughout it. The impossibility that seems to exist of getting either chemists or physicists to understand that the method of examining curves which we have employed does *not* involve the use of any equation at all is indeed extraordinary. My own opinion on the use of equations will be best illustrated by the following extract from my paper:—"It is necessary to say a word at starting to correct an erroneous opinion which is prevalent as to the method of examining curves which I have adopted. . . . It is imagined by many that this method consists in fitting sundry equations to the curves, and, on the strength of their concordance with these equations, to conclude that they are continuous or otherwise. Now, it is quite true that if a curve differentiates into a straight line after a certain number of differentiations, an equation of a certain form must represent that curve, and if it yields several straight lines there must be as many different equations applicable to different parts of it; but it is one thing to find equations empirically, and prove (?) their truth by a display of those most fallacious of arguments known as tables of 'found' and 'calculated' values, and another thing to apply an ordinary process of mathematical analysis to the curves, letting them speak for themselves, and tell us whether they are continuous or not. On the former of these methods I would place absolutely no reliance, and so far have I been from making use of it, that I have not found the equation for any single curve here depicted, and have purposely avoided finding any. The mathematical argument on which this work depends is, that a curve, if it be continuous, will on differentiation give either a straight line or another continuous curve, whereas, if it be not continuous, but be made up of different curves, will yield on differentiation a series of straight lines or curves. This, I think, is an incontestable fact."

That the majority of chemists are not mathematicians I willingly admit; this painful fact is shown only too clearly by their blind acceptance as gospel truth of everything which is "proved" mathematically. But Prof. Lodge must do us the justice to admit that we have occasionally some glimmers of common-sense, glimmers which would be inconsistent with our assuming that a certain curve was a parabola, and then being pleased, or even surprised, that it behaved after the manner of parabolas.

However much I may envy the powers of a mathematician, and however firmly I may believe that chemical facts will eventually be translated into mathematical expressions, I feel that at the present day the introduction of mathematical formulæ into chemistry almost invariably involves the exclusion of common sense. It is curious that Prof. Lodge's letter should have been immediately followed by an article on chemical affinity, which, I think, will be found to give a striking illustration of this dictum. What may be termed the $x$ and $y$ theory of chemical action, studied on paper by Guldberg and Waage, and followed up in the laboratory by Ostwald, has led unfortunate chemists into a labyrinth of cumbrous mathematical expressions for erroneous facts, where the common-sense of Berthollet would have given them a simple explanation of all the true facts of the case (see Trans. Chem. Soc., 1889, 26).

Harpenden, July 22. SPENCER PICKERING.

P.S.—Since writing the above I have obtained the most absolute justification of my method of differentiation which could possibly be obtained. I have isolated in the solid crystalline form a new hydrate of sulphuric acid, the existence of which I had predicted from an examination of the density and heat results of solutions of the acid. A few further details on the subject will, I believe, be found in the last issue of the *Chemical News*. S. P.

Ilfracombe, August 4.

## PHOTOGRAPHIC STAR-GAUGING.

THE mere equal-surface counting of the stars visible with the same instrument in different sections of the sky gives results open to misinterpretation. Admirable in itself, the method fails because it encounters what we may call "systematic errors" in the distribution of the stars. With incidental anomalies it is fully competent to deal; they should, on a large average, be mutually compensatory; but it breaks down before the clustering tendency which pervades, more or less markedly, the entire sidereal system. Not only are certain parts of space more crowded than others, but the crowded parts are related according to an obvious plan. They do *not* occur casually. Their effect is then heightened, instead of being eliminated, by multiplied observations.

The present resources of science, however, seem to offer the means of discriminating, to some extent, between real crowding and the simple extent of star-strewn space. Although the total number of the stars visible in each case with the same telescope might be precisely the same, their relative numbers, counted by magnitudes, would in all probability be very different. In a stratum, supposing the distribution of the stars equable, and their size uniform, their numbers should be nearly quadrupled at each descent of a magnitude. This of course is an ideal law of progression which we cannot expect to find anywhere strictly obeyed; but even approximate conformity to it must be held to indicate with tolerable certainty that the lessening ranks of the stars are, on the whole, at distances from us corresponding with their light. Now it *is* approximately conformed to by the stellar multitude down to about 8·9 magnitude over the general expanse of the sky, as well as over the zone of the Milky Way. But in that zone, stars of the ninth and higher magnitudes very much exceed their due numerical proportions; in other words, they are physically, no less than optically, condensed.

From these circumstances two very important inferences may be derived: first, that the lower margin of the galactic aggregations lies at a distance from us corresponding roughly to the mean distance of a ninth magnitude star, costing light some fourteen hundred years of travel; next, that the aggregated objects are average stars, neither larger nor smaller than those in our nearer neighbourhood. Both conclusions seem inevitable should the facts turn out, on closer investigation, to be as above stated. A regular increase in the numbers of the successive photometric orders of stars, tallying with the increased cubical contents of the successive spheres of which the radii are the theoretical mean distances of those same orders, affords strong, if not demonstrative, evidence of a corresponding real penetration of space.[1] And since the sequence continues unbroken down just to the ninth magnitude, we see that the galactic condensations of ninth magnitude stars cannot be situated nearer to us than their brightness would lead us to suppose—cannot, in other words, be stars on a lower than the ordinary level of lustre.

It is tolerably certain, however, that the denser star-clouds of the Milky Way lie far beyond ninth magnitude distance. The ground for this assertion is not the apparent minuteness of their components, but the singular fact, adverted to by Argelander, that, in the divided Milky Way, running from Cygnus to the Centaur, the

[1] The idea of determining distance by distribution seems to have presented itself to Dr. Gould in 1874. See *American Journal of Science*, vol. viii.

shining branches are nearly on a par with the dark rift separating them as regards the distribution of stars even fainter than the ninth magnitude. The nebulous effect to the eye distinguishing the branches is, then, presumably due to more remote collections. As to the further limits of these, we know as yet nothing, except that Herschel's gauge-numbers left it to be inferred that "thinning-out" had become marked before the attainment of fourteenth magnitude distance. On these, and similar subjects, enlightenment may be hoped for through the judicious use of means already at hand.

For simple star-counts, we have only to substitute star-counts by magnitudes over selected areas of the sky.[1] The relative numbers of the photometric ranks can hardly fail to give highly valuable indications as to real distribution; provided only that the assumption of a general uniformity in the brightness of the stars be valid. Not, it need scarcely be said, of a uniformity such as to preclude any extent of individual variety; all that need be supposed is, that the average size of a star remains constant throughout sidereal space. This hypothesis has far more probability in its favour than any other which could be set up instead of it; though it may receive corrections as our inquiries advance.

The photometric classification of small stars is one of the many branches of sidereal science which will henceforth be prosecuted only with the assistance of the camera. Visual methods are inadequate and insecure. Those by photography, it is true, have also their difficulties, not yet completely vanquished: they will, however, evidently prove manageable. Prof. Pickering is tentatively establishing methods in photographic photometry which will doubtless before long be brought to perfection. They depend mainly upon comparisons of stellar impressions upon any given plate, exposed under known conditions, with standard impressions of standard stars obtained with varied exposures or apertures. For the purpose we have in view, accidental errors of estimation, even if very large in amount, are of no importance. What is essential is, that the integrity of the series should be preserved—that the proportionate change of light from one magnitude to the next should remain invariable from the first term to the last. The realization of this aim, now virtually attained, is one of the most weighty services rendered to astronomy by the sensitive plate.

We may now describe the process of photographic star-gauging. It consists in the enumeration, by magnitudes or half-magnitudes, of the stars down, say, to the fifteenth magnitude, self-pictured from distinctively situated patches of the sky. Each such area should be wide enough to insure the elimination of minor irregularities in distribution; but a single large field would often suffice to show the characteristic grouping of the smaller telescopic stars.

The Milky Way would naturally be the first subject of inquiry; and the comparison of several plates taken in different sections of its course might be expected to yield data of great significance as regards its constitution. From simply calling over the muster-roll by orders of brightness of the stars contained in them, answers may be derived to the following questions:—

(1) How far does the regular sequence of increasing numbers extend? That is, down to what grade of brightness do the stars continue nearly to quadruple with each additional magnitude?

(2) Is the progression interrupted by defect or excess, or by each alternately? In other words, does the stellar system embrace systematic vacancies, as well as systematic groupings?

(3) Supposing an accumulation of stars to set in at a definite stage of space-penetration, where does it stop? Down to what magnitude is the augmented ratio of increase maintained?

(4) Are there symptoms of approaching total exhaustion of the stellar supplies beyond?

These should be found in a concurrent decrease of density with brightness, "density" being understood as the proportion of the numbers present to the space *theoretically* available for stars of a given magnitude. For one of two things seems certain: either the thinning fringe of stars is composed of really small objects interspersed among larger ones; or of average stars at average distances from us, but further and further apart from each other. In the first case, the system ends abruptly; in the second, it is, as it were, shielded by outliers from the absolute void.

Particular attention should be paid to the differences of stellar distribution upon plates of the Milky Way proper, and of the dark aperture between its cloven portions. That this really forms an integral part of the galaxy is shown by the far greater profusion of small stars there than in the general sky at the outer margins of the galactic branches—a fact in itself fatal to the "spiral theory," by which the rift was interpreted as a *chink* of ordinary sky-background left by the interlacing, to the eye, of two great streams of stars, one indefinitely more remote than the other. From photographs we may now hope to learn what is the nature of the distinction between rift and branches—what are the magnitudes, relative numbers, and presumable mean distances, of the clustering stars present in the latter, but absent from the former.

Gauges taken in the neighbourhood of the southern "coal-sack" ought to prove instructive as to the nature of the nebulous stratum out of which it seems as if *scooped*. If the Milky Way be there shallower than elsewhere, a greater uniformity of lustre may be looked for among the stars composing it. No background profusely stored with lessening ranks will come into view, and stars below the average of those grouped in bright masses, representing their genuine companions, will be but scantily present.

Outside the Milky Way, two points suggest themselves as likely to be settled by photographic gauges. Argelander found that the faintest stars in the *Durchmusterung* were everywhere in excess of their due proportion.[1] Even at the galactic pole, their increase, as compared with the class next below, was sextuple instead of quadruple; in the undivided galactic stream it was 9½, in the rift 8½ times. If this semblance of crowding *in all directions* at about the mean distance of a ninth magnitude star be no accident of enumeration, then the Milky Way is only the enhancement of a phenomenon universally present, and the fundamental plan of the sidereal system must be regarded as that of a sphere with superficial condensation intensified in an equatorial ring. The counts, to settle this question, will have to extend over a considerable area.

The second point for photographic investigation refers to the limits of the system towards the galactic poles. There is reason to believe them comparatively restricted. M. Celoria, of the Milan Observatory, using a refractor capable at the utmost of showing stars of eleventh magnitude, obtained for a "mean sounding," at the north pole of the Milky Way, almost identically the same number given by Herschel's great reflector.[2] That is to say, *no additional stars were revealed by the larger instrument.* Should this evidence be confirmed, the boundary of the stellar scheme should here be placed at a maximum remoteness of 3500 years of light-travel.

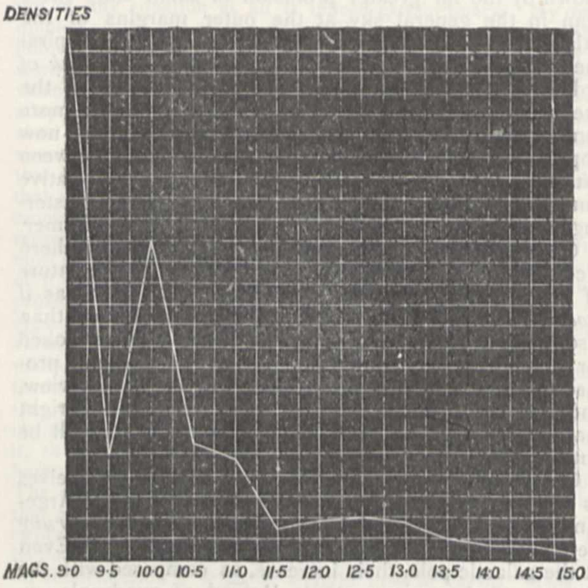
As a specimen of a photographic gauge-field on a small scale, we may take Prof. Pickering's Catalogue, from the Harvard plates, of 947 stars within 1° of the north celes-

[1] This plan was first suggested by Prof. Holden in 1883, as a mode of investigating the composition of star-groupings ("Washburn Publications," vol. ii. p. 113). Counts with varied telescopic apertures gave him the numbers in the successive photometric ranks. We believe that a photographic method of determining them has since been adopted by him.

[1] *Bonner Beobachtungen*, Bd. v. "Einleitung."

[2] *Memorie dell' Istituto Lombardo*, t. xiv. p. 86.

tial pole.[1] The region examined lies about 27° from the zone of the Milky Way, but is nearly reached by a faint extension from it Since only one eighth magnitude star, and none brighter, are included in it, the study of distribution, for which it offers some materials, may be said to begin with the ninth magnitude. A single glance at the synoptical table suffices to show that the numerical representation of the higher magnitudes is inadequate. The small stars are overwhelmingly too few for the space they must occupy if of average brightness; and they are too few in a constantly increasing ratio. Either, then, the diminishing orders form part of a heterogeneous collection of stars of all sizes at nearly the same distance from us (about that corresponding to ninth magnitude); or they belong to attenuated star-layers stretching to a much vaster distance. A criterion might be supplied by Prof. Holden's plan[2] of charting separately stars of successive magnitudes over the same area, and judging of their connection or disconnection by the agreement or disagreement in the forms of their groupings.




Distribution of 934 stars within 1° of the pole, showing the ratio of numbers to space for each half-magnitude.

The accompanying diagram shows graphically the decrease of density outward, deducible from Prof. Pickering's numbers on the sole supposition of the equal average lustre of each class of stars. Those of the ninth are the most closely scattered; the intervals between star and star widen rapidly and continuously (for the sudden dip at 9·5 magnitude is evidently accidental) down to 11·5 magnitude, when a slight recovery, lasting to the thirteenth magnitude, sets in. How far these changes are of a systematic character, can only be decided from far wider surveys. A. M. Clerke.

## *TWO AMERICAN INSTITUTIONS.*

### I.—The Smithsonian Institution.

In 1826, Mr. James Smithson, F.R.S., an English gentleman (a natural son of the first Duke of Northumberland), in a fit of pique at the action of the Committee of the Royal Society, who had declined to accept a scientific paper he had submitted, bequeathed to the United States of America a large sum of money, (£105,000), "to found at Washington under the name of the Smithsonian Institution, an establishment for the increase and diffusion of knowledge among men."

The question of how knowledge might be best increased and diffused with £105,000 then arose for discussion.

The President of the United States applied to a number of persons, "versed in science and familiar with the subject of public education, for their views as to the mode of disposing of the fund best calculated to meet the intentions of Smithson and be most beneficial to mankind."

The President of Brown University (Prof. Wayland) proposed a University to teach languages, law, and mental philosophy (Arts), without Science. Dr. Thomas Cooper, of South Carolina, proposed a University to teach science only, and to exclude Latin and Greek, literature, law, and medicine. Mr. Richard Rush proposed a Museum with grounds attached sufficient to reproduce seeds and plants for distribution; a press to print lectures, &c., and courses of lectures on physical and moral science, and on government and public law. The Hon. John Quincy Adams proposed the establishment of an astronomical Observatory, with instruments, and a small library. Prof. W. B. Johnson proposed the establishment of an institution for experimental research in physical science. Mr. Charles L. Fleischman proposed the establishment of an agricultural school and farm. The Hon. Asher Robbins proposed a literary and scientific institution; and memorials were presented to Congress in favour of appropriating the fund for annual prizes for the best original essays on the various subjects of the physical sciences; for the establishment of a system of simultaneous meteorological observations throughout the Union; for a National Museum; and for a Library.

For ten years the Congress of the United States wrestled with the interpretation of the words "the increase and diffusion of knowledge among men." The discussions were numerous and irritating; and it was repeatedly proposed to send the money back to England. Finally Congress was wise enough to aknowledge its own ignorance, and authorized a body of men to find some one who knew how to settle the question. Joseph Henry was chosen. His idea was accepted and acted upon. "To *increase knowledge* men were to be stimulated to original research by the offer of rewards for original memoirs on all subjects of investigation; to *diffuse knowledge* the results of such research were to be published;" and in addition it was decided to issue a series of reports giving an account of new discoveries in science, and of the changes made from year to year in all branches of knowledge not strictiy professional; as well as to publish occasionally separate treatises of general interest; and all these were to be distributed amongst the public institutions of the world.

In the result the Smithsonian Institution was established for the promotion of original research, and the diffusion of the same, and it now distributes to 3700 public institutions in Europe, Asia, Africa, and America, the following publications:—

"The Smithsonian Contributions to Knowledge," of which twenty-six volumes in a quarto series have been issued, comprising memoirs and records of original investigations; researches in what are believed to be new truths; efforts to increase human knowledge. "The Smithsonian Miscellaneous Collections," an octavo series, already numbering thirty-four volumes, containing reports on the present state of our knowledge of particular branches of science; instructions for digesting and collecting facts and materials for research; lists and synopses of species of the organic and inorganic world; reports of explorations; aids to bibliographical investigations, &c. "The Annual Reports of the Board of Regents of the

[1] *Harvard Annals*, vol. xviii. p. 138.
[2] Recommended in the *Century Magazine* for September 1838, as well as "Washburn Publications," vol. ii. p. 113.

Smithsonian Institution" (thirty-two volumes), containing also very valuable records, catalogues, and memoirs.

Another part of the income was applied in accordance with the requirements of the Act of Congress to the gradual formation of a library and a museum. But in 1866 the library was amalgamated with the Library of Congress and lodged in the Capitol. The Library, however is, open throughout the year with equal facilities for students, including the free use of the books of both collections. In 1852, Mr. Henry established what is known as the "Smithsonian system of exchanges," whereby, in exchange for those of America, the scientific publications of Societies and individuals throughout the civilized world are made accessible without cost to the students of science in America. This system has added to the Library almost complete series of the Transactions of many of the older Societies of England, France, and Germany, which it would now be difficult if not impossible to replace. They comprise hundreds of works which, like those of the Societies in question, can be obtained in no other way than by exchange. The collection is now the best in existence.

In his evidence before the Royal Commission on Scientific Instruction (English), June 1870, Mr. Henry said:—

"This is considered a very important part of the plan of operations. Not only are books distributed, but the Institution has commenced the practice of distributing specimens of natural history over the world and getting others in exchange. As an interesting fact in connection with this system, I may mention that all the lines of steamers convey the Smithsonian packages free of cost, and also that they are admitted through all Custom houses without being opened, and free from all duties in all countries."

This generous system is still in operation, and has been very much extended.

In 1858 the United States Government transferred the National Museum (established 1842) to the custody of the Smithsonian Institution with the same amount of annual appropriation ($4000) which had been granted to the United States Patent Office when in charge of it; but this annual appropriation has now been increased to about $40,000. A new Museum was built at a cost of $350,000.00, and at the last session of Congress a Bill appropriating $500,000.00 for the construction of a second Museum building passed the Senate, but was not brought to vote in the House of Representatives. The Secretary has no doubt, however, but that in a year or two a building much larger than the present one will be supplied.

The National Museum is in three divisions—the Museum of Record, the Museum of Research, and the Educational Museum—and there are departments, with twenty-four curators and sub-curators, of arts and industries, ethnology, antiquities, mammals, birds, fishes, comparative anatomy, mollusks, insects, marine invertebrates, invertebrate fossils, plants, minerals, lithology and physical geology, metallurgy and economic geology. There are, in addition, chemical and natural history laboratories, and a bureau of ethnology.

"So rapidly were the treasures of the Museum increased by the gathered fruits of various Government explorations and surveys, as well as by the voluntary contributions of the numerous and widespread tributaries of the Institution, that the policy was early adopted of freely distributing duplicate specimens to other institutions where they would be most appreciated and most usefully applied. And in this way the Smithsonian became a valuable centre of diffusion of the means of investigation. The clear foresight which announced that the Museum must soon outgrow the entire capacity of the Smithsonian resources was amply vindicated; but the strong desire of Joseph Henry to see established in Washington a *National* Museum he did not live to see gratified" ("Memorial of Joseph Henry," discourse of W. B. Taylor, p. 285). He died May 13, 1878.

An extensive system of meteorological observations was instituted in 1849. About six hundred observers, scattered over the United States and the Territories, became voluntary correspondents of the Institution. This department was transferred in 1872 to the newly-established Meteorological Department established by the Government under the Signal Office of the War Department. The digested observations have been published in the "Contributions to Knowledge."

The memoirs in the quarto volumes of the "Contributions to Knowledge" (over 120) are universally recognized as valuable original authorities on their respective topics. There is no restriction as to the subject of research, and they consist of archæological, anthropological, botanical, geological, palæontological, meteorological, magnetical, physical, physiological, and philological observations, investigations on the solar system, the laws of atmospheric circulation, and systems of consanguinity and affinity. They have undoubtedly tended "to increase and diffuse knowledge."

The thirty-odd volumes of the "Smithsonian Miscellaneous Collections" are of a more technical character than the "Contributions," including systematic and statistical compilations, scientific summaries, and valuable accessions of tabular "constants." Scientific men generally have applauded the value and acknowledged their indebtedness to publications comprised in this series, which include such scientific classics as Clark's "Constants of Nature," Guyot's "Meteorological and Physical Tables," Watson's "North American Botany," Binney and Tryon's "Land and Fresh-water Shells of North America"; North American "Coleoptera" by Le Conte, "Diptera" by Loew, "Lepidoptera" by Morris, and "Neuroptera" by Hagen.

All these are distributed over every portion of the civilized and colonized world, and constitute a monument to the memory of James Smithson, such as never before was built on the foundation of one hundred thousand pounds.

## II.—The Johns Hopkins University, Baltimore.

Johns Hopkins, a merchant of Baltimore, who died in 1873, in the seventy-ninth year of his age, bequeathed a large part of his fortune to two institutions which perpetuate his name—the Johns Hopkins University and the Johns Hopkins Hospital. Each foundation received an endowment of not far from three and a half million dollars, or about £700,000. The two institutions are separate corporations, but are closely affiliated. The University has just concluded its thirteenth year of work. Since its opening, in 1876, it has issued frequent statements of the development of its plans in the form of Annual Reports.

The Johns Hopkins University is an unsectarian foundation. There is no test for the assent of students or Professors. This is the especial privilege of the new institutions for higher education that have sprung up of late years. "No hungry tradition treads them down." They approach the problem of education untrammelled by customary practice; yet, utilizing the experience gained by the older Universities, they make more independent and original attempts at its solution.

Universities as a rule have grown from an aggregation of Colleges; the University, in process of time, being evolved as a supplement to collegiate training. The Johns Hopkins University is an exception to this rule. In accordance with the terms of the gifts, the institution started with the idea of the University, in the higher conception of that word, as a universal school and a fostering mother. Not merely a place in which degrees are granted in the Faculties of Arts, Sciences, Divinity, Law, or Medicine, but as an organized force for the education of the community of the district in which it is placed, for deepening, purifying, and strengthening all good influences on the men, and the alliance of the men with the institutions. Institutions remain, but the men pass away—

"The individual withers, and the world is more and more."

According to the thirteenth Annual Report of the University (September 1887 to September 1888), it appears that the academic staff included 57 Professors, Associate Professors, and Lecturers. There were 420 students; 199 were residents of Maryland, 196 came from other States of the Union, and 25 from foreign countries; 231 had already graduated, 127 had matriculated for the degree of B.A., and 62 were admitted as special students to pursue courses of study for which they seemed fitted, without reference to graduation. The University does not provide lodging or board.

There are seven distinct and parallel courses of College instruction adapted for matriculation, and the various elective groups for the degree examinations in the University. The subjects of the Professors and Lecturers last session were: history, political economy, mathematics, astronomy, physics, chemistry, mineralogy, geology, biology, psychology, pedagogics, pathology, Greek, Latin, Sanskrit, Indo-European philology, Shemitic languages, Romance languages, Teutonic languages, Anglo-Saxon, and English. The large and well-appointed physical, chemical, and biological laboratories of the University have already been detailed in NATURE (vol. xxxiii. p. 237).

Two degrees only are granted—the Bachelor of Arts and the Doctor of Philosophy; and since degrees were first conferred in 1878, 177 have attained the Baccalaureate degree, and 131 have been advanced to the degree of Doctor of Philosophy.

There are twenty Fellowships of $500 each. The examination for these is, in a certain sense, competitive, but not with uniform tests, nor by formal questions submitted to the candidates. The applicants' previous record, and the Professors' record, is taken into consideration.

"Those who are appointed are expected to proceed to the degree of Doctor of Philosophy. The appointments are not made as rewards for good work already done, but as aids and incentives to good work in the future; in other words, the Fellowships are not so much honour and prizes bestowed for past achievements, as helps to further progress and stepping-stones to honourable intellectual careers. They are not offered to those who are definitely looking forward to the practice of any one of the three learned professions (though such persons are not formally excluded from the competition), but are bestowed almost exclusively on young men desirous of becoming teachers of science or literature, or proposing to devote their lives to special branches of learning which lie outside of the ordinary studies of the lawyer, the physician, or the minister. Appointments are rarely, if ever, made of graduates of more than five years' standing."

There are also twenty graduate scholarships of $200 each for those who have taken the baccalaureate degree. There are also thirty-eight ordinary and honorary Hopkins Scholarships ($250 annually and free tuition) for promising young men.

Courses of public lectures, designed primarily for the members of the University, and supplementary to the regular class-room work, are given each session. The admission of the public is by ticket, to be previously obtained free. The courses for 1887-88 included: ten lectures on some of the problems of great cities; six lectures on the local study of natural history; nine lectures on the history of the science of electricity and magnetism; eleven lectures on the causes which led to the French Revolution; four lectures on Greek lyric poetry; eight lectures on the topography of Athens.

The University Library consists of 35,000 volumes. And it is lately reported that the valuable scientific collection of the Maryland Academy of Sciences has been presented to the University.

But the great point of this institution is its efforts in the direction of the endowment of scientific research. Prof. Newcomb, one of the Professors of the University, said in 1876 of America what is very true of Great Britain: "We are deficient in the number of men actively devoted to scientific research of the higher types; in public recognition of the labours of those who are so engaged; in the machinery for making the public acquainted with their labours and their wants; and in the preliminary means for publishing their researches." The Johns Hopkins University has encouraged scientific research, and the publication of its results, to a large extent; not only by training young men in the methods of exact science, and fitting them for the scientific service of the Government, for scientific and technical laboratories, and for the teaching profession, but also by the publication of journals and monographs detailing the results of scientific study. The trustees, determining to encourage the heads of departments and other qualified scholars to contribute each in his own way to the advancement of the science which he professed, started five periodicals, conducted by Professors and graduates, and aided by the University chest, namely: *The American Journal of Mathematics*, 10 vols., edited by Prof. Newcomb; *The American Chemical Journal*, 10 vols., edited by Prof. Remsen; *The American Journal of Philology*, 9 vols., edited by Prof. Gildersleeve; *Studies from the Biological Laboratory*, 4 vols., edited by Prof. Martin and Dr. Brooks; and the *Johns Hopkins University Studies in Historical and Political Science*, edited by Prof. H. B. Adams, the seventh series of which is in progress. All of these publications are considered on both sides of the Atlantic to be of the greatest value. *The American Journal of Psychology*, *Modern Language Notes*, and *Contributions to the Study of Archæology*, are also edited by members of the academic staff, and there are University Societies on all these subjects.

The University also publishes *University Circulars* monthly, containing scientific notes in biology, chemistry, history, political science, mathematics, physics, philology, philosophy, logic, &c., besides the usual Annual Reports and special publications, such as the "Reports of the Chesapeake Zoological Laboratory." This is a laboratory of about fifty individuals at ten stations, and the results of their work at the sea-shore, in the study of natural laws in their simplest manifestations, from 1879 to 1886 include ninety-nine titles.

Dr. Gilman, the President of the University, reported at the tenth anniversary that 176 former students were known to be engaged in the work of teaching, mostly in colleges; and that among the former pupils are eighty physicians, thirty-eight ministers, and thirty-four lawyers. There were no exact statistics of those engaged in scientific pursuits.

Such are the beginnings of the Johns Hopkins University. Those engaged in the work of higher education in this country will appreciate fully the fortunate circumstances in the inception of the institution: a benefaction of £700,000 for endowment; carefully selected trustees, to whose wisdom, moderation, and far-sightedness much is due; a wisely organized constitution; able Professors and teachers, gauged by the standard of work done and success achieved; and foundations to assist all these contributed by a critical and discerning public. The institution started full of promise, and it is redeeming its promise with a rapidity unparalleled in the history of academic institutions.

J. TAYLOR KAY.

## THE MEETING OF THE BRITISH ASSOCIATION AT NEWCASTLE-ON-TYNE.

THE arrangements of the Local Committee are nearly completed for the reception of the British Association on the occasion of its fifty-ninth annual meeting, which, as our readers are aware, is to be held in Newcastle-on-Tyne, and will commence on September 11. This will be the third occasion on which the Association has held its annual Congress in Newcastle-on-Tyne, the last being in 1863—a meeting memorable as being the largest gathering of members and friends of the Association, which has only been once exceeded in point of numbers, viz. by the Manchester meeting of 1887. No efforts have been spared on the part of the Committee to make preparations for a meeting which, it is hoped, will prove as successful and interesting to the members as the former meeting proved; and in their endeavours to do this, the work of the Committee has been greatly facilitated by the many notable additions, in the shape of buildings suitable for the purposes of the Association, which have been erected since 1863.

The reception-rooms, occupying a central position with respect to the various Section rooms, will be located in the new buildings of the University of Durham College of Medicine, Bath Road, in which building a writing-room and ladies' drawing-room will be provided, also special rooms for the use of the officers of the Association. The Cambridge Drill Hall, near the reception-room, is to be fitted up for a luncheon-room. Sections A and B will meet in the new buildings of the College of Science, opened in November last by H.R.H. Princess Louise; and in the chemical laboratory of this College it is intended to bring together a series of exhibits illustrating the chemical and allied manufactures of the district. The general meetings of the Association will be held in the St. George's Drill Hall.

The Natural History Museum, opened by H.R.H. the Prince of Wales in 1884, in which building is Mr. Hancock's unique collection of British birds, will be used for the two *soirées;* the first is to be given by the Mayor and Corporation, and the second by the Local Committee.

A guide-book, arranged in three sections, has been prepared for the occasion of the Association's visit, dealing respectively with the history and topography, the geology and natural history, and the industries of the district. The first section is edited by the Rev. J. Collingwood Bruce; the second by Prof. Lebour; and the third by Mr. Wigham Richardson.

The Durham, Northumberland, and Newcastle-on-Tyne Botanical and Horticultural Society has arranged to hold its autumn show during the time of the meeting, and on Wednesday, September 11—the first day of the show—it will be open to members free on presentation of their tickets.

On the Saturday, half-day excursions have been arranged to the following places of interest: Morpeth, Wallington, Seaton Delaval, Hexham, Marsden, Prudhoe, Durham, and an excursion down the river. The Senate of the University of Durham proposes to hold a special Convocation on the Saturday for the purpose of conferring honorary degrees on the President and other officers of the Association. Convocation will be followed by a luncheon, to which 200 members of the Association will be invited, after which there will be a special service in the Cathedral.

Thursday, the last day of the meeting, is to be devoted to whole-day excursions to the following places: Alnwick, Cragside (the seat of Lord Armstrong), Middlesbrough, Berwick, Lanercost, Beal, Little Mile, Belford, Raby, Bardon Mill, and Middleton-in-Teesdale.

The principal works in Newcastle and on the Tyne will be thrown open to members for inspection during the meeting.

The railway company is prepared, during the meeting, to issue tickets at reduced rates to and from places in the neighbourhood, and to run special trains, so that members, should they wish to do so, will be able to reside in the country or on the coast, and get to and fro conveniently. Through the kindness of the authorities of University College and of Hatfield Hall, Durham, the Local Committee are enabled to place the students' rooms in these buildings on their hotel and lodgings list, which list will also be found to contain the addresses of several places in Tynemouth, Cullercoats, and Whitley, on the coast.

## THE NEW BUILDINGS OF THE SORBONNE.

IN England we are still fighting about the question whether London is or is not to have a teaching University. It is significant that Frenchmen have no sort of doubt as to the necessity of such an institution in Paris. During the long and splendid history of the Sorbonne they have had ample experience of the value of a great teaching body in the capital; and the result is that this is one of the institutions in which men of all parties take a common pride.

So long ago as 1855 it was decided that new buildings for the Sorbonne should be erected, but the scheme was not really complete until 1881. It was then estimated that the expense would be 22,000,000 francs—a formidable enough sum, but one which caused no serious difficulty, as the city readily undertook to contribute half of it. The foundation was laid in 1885, and now a considerable part of the work is finished. This was opened on Monday, in the presence of the Head of the State, and the ceremonies on the occasion may be regarded as affording fresh evidence of the enthusiasm felt by educated Frenchmen for all that represents and tends to develop the highest intellectual life of the nation. Every University had been asked to send delegates elected by the students to the celebration; and the State, and the City of Paris, agreed to look upon them as their guests during the ten days of festivity in honour of science. "This part of the programme," says the Paris Correspondent of the *Daily News*, "has been well carried out, arrangements having been made with different hotels to board and lodge the foreign visitors at the expense of the Hôtel de Ville and the Ministry of Public Instruction. Russia and Germany have not accepted invitations, but the Universities of Great Britain, of the Scandinavian countries, of Belgium, Holland, Greece, Switzerland, Italy, Spain, and the United States are represented. There are about 700 delegates from these countries, besides a large number who have come at their own expense."

The *fêtes* began on Sunday evening with a gala performance of "Faust" at the Opera House, which the President attended. On Monday, 3000 persons assembled in the new amphitheatre, an immense hall adorned with frescoes. Each delegation had a standard-bearer carrying the flag of his nation, and the members of the various groups were warmly greeted by the public as they advanced to the places appointed for them. At 3 o'clock M. Carnot arrived, and took his seat on the platform, surrounded by Ambassadors, statesmen, and Academicians. M. Ferry, as the Minister who made the arrangements for the enlargement, was much cheered.

M. Gréard, Rector of the Academy, made the first speech. He sketched the history of the Paris University, extolled the events of 1789, and described study as a common Fatherland, which had brought together delegates from nearly all the European and American Universities. M. Hermite next reviewed the mathematical teaching of the Sorbonne since 1808. M. Chautemps, President of the Municipality, vindicated democracy from the imputation of indifference to culture, and claimed credit for the body represented by him for having founded a Chair of French Revolution History and a Chair of Evolution. M. Fallières, Minister of Education, dwelt on the efforts and sacrifices of the Republic for the diffusion of culture. He referred to the moribund condition of the Universities on the eve of the Revolution, and the want of cohesion between the colleges afterwards established, and eulogized the individuality now developed by the provincial Universities.

## NOTES.

AT the annual graduation ceremony at the close of the summer session of the University of Edinburgh, last week, Prof. T. R. Fraser intimated that the important Cameron Prize in Therapeutics, the recipient of which might be selected from any country, had been awarded to M. Pasteur, a Doctor of Laws of Edinburgh University, in recognition of the high importance and great value in practical therapeutics of the treatment of hydrophobia discovered by him.

THE fifty-seventh annual meeting of the British Medical Assotion will begin at Leeds on Tuesday, the 13th inst., and go on until the 16th, under the presidency of Mr. C. G. Wheelhouse. The President's address will be delivered on the evening of the 13th. On the 14th, an address in medicine will be given by Dr. Hughlings Jackson, F.R.S., and afterwards the Stewart Prize will be presented to Dr. Klein, F.R.S., for his work in bacteriology and scarlet fever. On the 15th, an address in surgery will be given by Dr. Pridgin Teal, F.R.S., and on the 16th, Sir James Crichton Browne, F.R.S., will deliver an address in psychology.

AT the Academy of Medicine, Paris, in the grand amphitheatre, a numerous and distinguished audience gathered on Sunday for the first sitting of the International Congress of Hygiene. The chair was taken by Prof. Brouardel, with Dr. Chautemps, President of the Paris Municipal Council, and Sir Douglas Galton as Vice-Presidents. Sir Douglas Galton returned thanks on behalf of the various English Sanitary Societies, represented at the Congress by ten English delegates. He promised a hearty welcome to the French hygienists, who, he hoped, would in great numbers attend the next International Congress, to be held, as arranged, in London in 1891. The work of the Congress began in earnest on Monday, and among the subjects discussed was a proposition submitted by Dr. Jablowski, the Russian delegate, to the effect that children suffering from tuberculosis of the lungs, or even only suspected to have this complaint, should be sent back from school to their families. This proposal was rejected, but it was considered that the school doctor should exclude such pupils as by the dangerous character of their expectorations might spread the specific germ of pulmonary consumption. On Tuesday there was a discussion on the inspection of unwholesome dwellings; and in connection with "the dust-bin grievance" the Congress unanimously passed a resolution that kitchen refuse should never be kept in the house over night, that it should be placed outside in metallic boxes, and that it should be removed every twenty-four hours.

IN his interesting speech on the Education Estimates on Monday, Sir W. Hart Dyke had much to say about the new Code, the enforcing of which he has been obliged to postpone. He showed that it would "open and widen the curriculum," and referred especially to the advantages it would confer on small schools in the midst of a scattered agricultural population. The mass of our agricultural schools in England and Wales did nothing but just pass their scholars through the elementary subjects. Both sides of the House regarded that as a most deplorable thing. Questions had been put to him from time to time as to teaching agriculture in the rural schools. Knowing something of rural school life, he should do nothing so absurd as to attempt to turn out first-rate agriculturists from our elementary schools. But there was a vast difference between that and turning children out knowing nothing of plants or botany or of insect life, and what was useful and what was injurious to agriculture. A vast deal of good might be done by training in regard to these matters. What they proposed to do was to provide that any scholar might attend elementary science classes at district centres. At present, in towns as well as in agricultural districts, more combination was required between schools to enable them to carry out different kinds of teaching. What one school was unable to do, a group of three or four, with little trouble and with an economy of expenditure, might readily carry out. Sir John Lubbock and Sir Henry Roscoe expressed much regret that the new Code had been for the present withdrawn, and hoped that it would be introduced again next session.

THE committee of the national association for the promotion of technical education have issued their second annual report. They think they may fairly congratulate the members on the progress made by the movement during the past year. On May 1, 1888, an anonymous donor offered to contribute £500 to the funds of the association, provided £1000 were raised from other sources before May 1, 1889. The support received from the public has been such that the committee have secured this donation. They refer with especial satisfaction to the support received from representative bodies of working men. No fewer than thirty-one working men's Co-operative Societies have given donations or subscriptions during the year, and many more are in complete accord with the aims of the association. The committee hope that with the resources now at their disposal they may be able to extend their work, particularly in the department of secondary education, but they appeal for a larger number of annual subscriptions. Nothing has occurred to weaken their belief in the magnitude and urgency of the work which needs to be carried out to improve, develop, and harmonize, and bring into close relations one with another, the elementary, secondary, and technical education of the country.

THE establishment of a technical school at Frankfort-on-Maine for young artisans and mechanics was planned long since by different corporations in that city, and from a statement made lately by the mayor, it appears that all the expenses in connection with the school are to be borne by the city, which will also give the rooms and see to the appointment of the teachers. The lessons will be given on Sundays and in the evening on week days. The pupils will be charged a very moderate tuition fee only. Great energy is displayed in order to open this school very shortly, says the British Consul in his last Report, as the accomplishment of the scheme will be hailed with great satisfaction throughout the city.

THE death of Mr. C. Spence Bate, F.R.S., at Plymouth, is announced. He was the author of the "Report of the Crustacea Macrura dredged by H.M.S. *Challenger*, during the years 1873–76." He was also the author of the "Catalogue of the Specimens of Amphipodous Crustacea in the Collection of the British Museum"; and of a work on "The Pathology of Dental Caries." In conjunction with Mr. J. O. Westwood, Mr. Bate wrote "A History of the British Sessile-eyed Crustacea."

DURING last week Mr. John Aitken visited the Ben Nevis Observatory in connection with the proposed investigation into the number of dust particles in the atmosphere. From observations made by him and Mr. Omond, the numbers varied from 350 per cubic centimetre about noon to 500 at 3 p.m. The purest air previously examined by Mr. Aitken was on the Ayrshire coast, and gave 1260 dust particles to the cubic centimetre. It is, of course, premature to draw conclusions from these observations, but it may be suggested that extended observation will in all probability establish the fact of the singular purity of the air at this height, as compared with that at lower levels; and that the numbers of dust particles will be greatest at the Observatory in that part of the day when the ascending currents up the heated sides of the mountain are strongest.

REFERENCE was made in our last issue (p. 326) to the drought on the top of Ben Nevis in June last. In that month the hours of sunshine registered by the sunshine recorder were 250, a number considerably in excess of any previous month, the highest having been 206 hours in June 1887. With the early disappearance of the snow and strong sunshine of June, such vegetation as is found at these heights is well forward. On July 22, fine specimens of *Silene maritima*, about 8 inches in height, well grown, with abundant flowers, many of them in seed well matured, were gathered on Cairn Dearg, one of the lower heights of the mountain, at a height of 3800 feet above the sea. In Hooker's "Flora of the British Islands," the limiting height of this plant is given at 3000 feet.

THE Report of the Director of the Hong Kong Observatory, for 1888, has been issued. It is an interesting and exhaustive document. In reference to thunderstorms in the colony during the past five years, Dr. Doberck states that they are most frequent in May, and that they have not occurred in November, December, and January. They seldom happen in February. With reference to the daily variation, they are more frequent at night than during the day-time in the proportion of three to two. They appear to be most abundant about 1 a.m., and least so about 8 a.m., in the proportion of about two to one. During the past year the temperature was on an average higher than in previous years, and rose higher than before on hot days. This appears to have been at least partly due to a more southerly direction of the wind, but the temperature has been rising on the whole since 1884. Whether this is periodical remains to be investigated. The Director thinks there are fair prospects of finding it is so. The past year was more damp than usual, the rainfall was heavy, and the mean barometer below the average. The amount of sunshine was less, and the cloudiness greater than usual. It is generally considered to have been an unhealthy year.

*Science* says that in 1887–88 the courses in astronomy at the Johns Hopkins University were so extended as to justify its being chosen as a principal subject by candidates for the degree of Doctor of Philosophy. A small observatory has been erected, and is fitted up with a meridian circle by Fauth and Co., a portable transit instrument by Troughton, a clock, a chronograph, and other subsidiary apparatus. In the dome of the physical laboratory is mounted an equatorial of 9½ inches aperture, so fitted that the student can learn to make the usual determinations with the largest instruments of that class. The work in astronomy consists of a study of the history and practice of the subject, supplemented by instruction in the use of the instruments, and exercises in astronomical computation. During the year 1889–90 the courses are intended to cover a wider range of individual subjects than usual.

THE Royal Society of New South Wales offers its medal and a money prize for the best communication (provided it be of sufficient merit) containing the results of original research or observation upon each of the following subjects. To be sent in not later than May 1, 1890:—The influence of the Australian climate (general and local) in the development and modification of disease—the Society's Medal and £25; on the silver ore deposits of New South Wales—the Society's Medal and £25; on the occurrence of precious stones in New South Wales, with a description of the deposits in which they are found—the Society's Medal and £25. To be sent in not later than May 1, 1891:—The meteorology of Australia, New Zealand, and Tasmania—the Society's Medal and £25; anatomy and life-history of the Echidna and Platypus—the Society's Medal and £25; the microscopic structure of Australian rocks—the Society's Medal and £25. The competition is in no way confined to members of the Society, nor to residents in Australia, but is open to all without any restriction whatever, excepting that a prize will not be awarded to a member of the Council for the time being; neither will an award be made for a mere compilation, however meritorious in its way. The communication, to be successful, must be either wholly or in part the result of original observation or research on the part of the contributor.

AT a recent meeting of the Genevan Society of Physics and Natural History, M. Mallet exhibited two balls of almost perfect sphericity, about 4 inches in diameter, one black, and of vegetable origin, the other white, and of mineral origin, but both produced by a mechanical movement. The black ball had been found with another in a piece of oak which had long served as the shaft of a mill-wheel. A cavity having formed in the wood, through disease or the work of some insect, the dust of the wood, with acquired moisture, had been rolled into this spherical form, growing in size, like a snowball (a slow process of many years probably, as the wheel was very old). The white ball, a calcareous pebble, was found with many others in a grotto traversed by a torrent which flowed into the Rhone.

FOUR years ago a light-ship was stationed in the Baltic, between the Islands of Bornholm and Rügen, and the currents there have been measured on 294 days in a year, every two hours, with interesting results (described by Herr Dinklage in the *Annalen der Hydrographie*). It is found that the currents vary most irregularly in direction, strength, and duration, but in most cases follow the prevailing winds (of which the westerly are the most frequent). Currents which did not diverge more than 90° from the wind's direction being counted as similar in direction, 86 per cent. were of this nature. The relation becomes more pronounced when only winds and currents above a certain limit of force are considered. A sudden change in direction of wind is soon followed by a change in that of current. The effect of wind direction on current direction is certainly apparent the first day, and to a depth of at least 5 metres. The direction of current rarely coincides exactly with that of wind, and divergence to the right is distinctly more frequent than divergence to the left. As this cannot be attributed to the form of neighbouring coasts or to the circulation of winds (for winds in our latitudes turn mostly the other way), the author regards the effect as due to the rotation of the earth.

THE Northern Lighthouse Board have adopted Priestman's oil engines for blowing fog signals in preference to steam or gas engines. A great saving is thus effected in first cost, no chimney being required as in the case of a steam engine, nor gas works, which would be needful if a gas engine were adopted.

THE first part of the Journal of the College of Science of the Imperial University of Japan, which has just been published, contains two papers illustrated by numerous excellent plates. The first is by Prof. Matsujiro Yokoyama, on the subject of "Jurassic Plants from Kaga, Hida, and Echizen," three provinces on the west coast of Japan. It is a valuable contribution to our knowledge of the fossil flora of Japan, a subject hitherto little investigated. Prof. Yokoyama's specimens were collected, for the most part, by the Geological Survey of Japan.

His descriptions and classification show a thorough acquaintance with the subject. The conclusion he arrives at is that the "Jurassic flora of Kaga, Hida, and Echizen belongs to the same geological horizon as the flora of Siberia, Spitzbergen, and Yorkshire—namely, to the Bathonian stage of the Inferior Oolite with special relations to the flora of Siberia." The second paper is by Prof. Yasushi Kikuchi, on "Pyroxenic Components in certain Volcanic Rocks from the Bonin Islands."

IN his Annual Report on Education in Hong Kong, Dr. Eitel, the Government Inspector of Schools, says that the total number of educational institutions of all descriptions known to have been at work in the colony of Hong Kong during the year 1888 amounts to 206 schools, with a grand total of 8717 scholars. More than three-fourths of the whole number of scholars—that is to say, 6728—attended schools (99 in number) which are subject to Government supervision, and either established or aided by Government in some form or other. The remainder—viz. 107 schools, with 1989 scholars—are private institutions entirely independent of Government supervision, and receiving no aid from public funds, except that they are exempt from payment of rates and taxes.

M. TAUPIN, who was recently despatched by the Governor-General of French Indo-China to the Laos States on an exploration, has presented a report of the results, which he sums up as follows:—"I have studied the language and system of writing of the Laos—that is, of the only population in the world possessing a graphic-alphabetical system. Of this there has been up to the present no positive knowledge. It was only known that the Laotian language and writing were somewhat similar to those of Siam. The language is spoken by about four millions of people. I have collected interesting information relating to the natural history of these regions, and much commercial information. . . . I have made numerous meteorological observations, and taken a large number of anthropometrical measurements according to the Broca system."

IN the *Izvestia* of the Moscow Society of the Friends of Natural Science, vol. lxiii., there is an exhaustive work, by M. Kharuzin, on the Kirghizes. The anthropological data relative to the great Bukéeff stem are fully presented, and illustrated by sixteen photographs. The writer also describes the religious beliefs of the Kirghizes, their religious festivities and worship, and their customary law. An appendix contains the results of the excavation of thirty-six *koorgans* in the Kirghiz Steppe.

THE Governor of Jamaica, in his Report regarding the progress of the colony during the past year, says that the Department of Public Gardens and Plantations has done much useful work, and that the distribution and collection of valuable economic plants have been actively carried on. The Hope Gardens, which are intended to take the place of those at Castleton, as the head botanical station, have made good progress, but as they are young, and the authorized annual expenditure limited, some time must elapse before they will be complete. Although they are 19 miles from Kingston, they attract a large number of visitors. At the cinchona plantation actual cultivation has ceased so far as planting operations are concerned, but the establishment of a hill garden there has been attended to. No cinchona bark was shipped during the year, but bark has been supplied to the Government analytical chemist for preparation of a liquid extract of a febrifuge manufactured according to a method adopted by Mr. Hooper, Government Quinologist in the Nilgiris, and which is to be tested by the Medical Department of the colony. Attention is directed to the propagation at Castleton of the Manilla hemp plant with a view to its introduction into different parts of the island, and it is pointed out that even if the fibre is not utilized as an article of export, it may supply a local demand for rope, and so save such a valuable timber-tree as the "mahoe," of which large numbers are annually destroyed by the peasantry by being stripped of their bark, which is twisted into ropes. Another interesting circumstance alluded to is the successful experiment of grafting the mangostien (which, although growing at Castleton for many years, has only recently reached the fruiting stage) upon the gamboge tree of common growth.

THE additions to the Zoological Society's Gardens during the past week include a Macaque Monkey (*Macacus cynomolgus* ♀) from India, presented by Mr. H. J. Cunnington; a Peregrine Falcon (*Falco peregrinus*), captured at sea, presented by Captain Watson; an Indian Fruit Bat (*Pteropus medius* ♂) from India, presented by Mr. Tholen; an Ocelot (*Felis pardalis*) and a Brazilian Cariama (*Cariama cristata*) from South America, presented by Captain W. Heathorn Lacy; a Tuberculated Iguana (*Iguana tuberculata*) from Brazil, presented by Mr. H. E. Blandford; three Palm Squirrels (*Sciurus palmarum*) from India, purchased; an Indian Python (*Python molorus*) from India, deposited; and ten Gold Pheasants (*Thaumalea picta*), bred in the Gardens.

## *ASTRONOMICAL PHENOMENA FOR THE WEEK* 1889 *AUGUST* 11–17.

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

*At Greenwich on August* 11

Sun rises, 4h. 41m.; souths, 12h. 4m. 56·3s.; daily decrease of southing, 9·7s.; sets, 19h. 28m.: right asc. on meridian, 9h. 25·5m.; decl. 15° 9′ N. Sidereal Time at Sunset, 16h. 50m.

Moon (Full on August 11, 5h.) rises, 19h. 36m.*; souths, 23h. 58m.*; sets, 4h. 28m.: right asc. on meridian, 21h. 16·5m.; decl. 18° 54′ S.

| Planet. | Rises. h. m. | Souths. h. m. | Sets. h. m. | Right asc. and declination on meridian. h. m. | ° ′ |
|---|---|---|---|---|---|
| Mercury.. | 4 56 ... | 12 22 ... | 19 48 ... | 9 43·2 ... | 15 34 N. |
| Venus ... | 1 3 ... | 9 5 ... | 17 7 ... | 6 25·0 ... | 21 17 N. |
| Mars ... | 3 4 ... | 11 1 ... | 18 58 ... | 8 21·3 ... | 20 34 N. |
| Jupiter ... | 16 39 ... | 20 32 ... | 0 25*... | 17 54·4 ... | 23 24 S. |
| Saturn ... | 5 1 ... | 12 23 ... | 19 45 ... | 9 43·7 ... | 14 53 N. |
| Uranus ... | 10 20 ... | 15 49 ... | 21 18 ... | 13 10·3 ... | 6 50 S. |
| Neptune.. | 23 1*.. | 6 51 ... | 14 41 ... | 4 10·9 ... | 19 25 N. |

* Indicates that the rising and southing are those of the preceding evening and the setting that of the following morning.

| Aug. | h. | |
|---|---|---|
| 11 ... | 14 ... | Mercury in conjunction with and 0° 38′ north of Saturn. |
| 16 ... | 14 ... | Saturn in conjunction with the Sun. |

*Variable Stars.*

| Star. | R.A. h. m. | Decl. ° ′ | | h. m. | |
|---|---|---|---|---|---|
| *o* Ceti (Mira) ... | 2 13·7 ... | 3 28 S. ... | Aug. 11, | | *M* |
| δ Libræ ... ... | 14 55·1 ... | 8 5 S. ... | ,, 15, | 1 40 | *m* |
| V Coronæ ... ... | 15 45·6 ... | 39 54 N. ... | ,, 11, | | *M* |
| U Ophiuchi... ... | 17 10·9 ... | 1 20 N. ... | ,, 13, | 1 36 | *m* |
| | | and at intervals of | | 20 8 | |
| X Sagittarii... ... | 17 40·6 .. | 27 47 S. ... | Aug. 12, | 0 0 | *M* |
| | | | ,, 16, | 3 0 | *m* |
| W Sagittarii ... | 17 57·9 ... | 29 35 S. ... | ,, 11, | 3 0 | *M* |
| U Aquilæ ... ... | 19 23·4 ... | 7 16 S. ... | ,, 15, | 0 0 | *m* |
| η Aquilæ ... ... | 19 46·8 ... | 0 43 N. ... | ,, 15, | 3 0 | *M* |
| R Sagittæ ... ... | 20 9·0 ... | 16 23 N. ... | ,, 16, | | *m* |
| W Cygni ... ... | 21 31·9 ... | 44 53 N. ... | ,, 11, | | *m* |
| δ Cephei ... ... | 22 25·1 ... | 57 51 N. ... | ,, 15, | 2 0 | *M* |

*M* signifies maximum; *m* minimum.

*Meteor-Showers.*

| | R.A. ° | Decl. ° | |
|---|---|---|---|
| The *Perseids* ... ... ... | 44 ... | 56 N. ... | Swift; streaks. |
| Near μ Persei ... ... ... | 60 ... | 48 N. ... | ,, ,, |
| ,, η Aurigæ ... ... | 74 ... | 41 N. ... | ,, ,, |
| ,, δ Draconis ... ... | 290 ... | 70 N. ... | Swift. |

*Ephemeris of Comet Davidson (by Krueger).*

| Greenwich Civil Time. h. | | Right Ascension. h. m. s. | | Declination. ° ′ |
|---|---|---|---|---|
| August 10...0 | ... | 15 7 26 | ... | 8 15 N. |
| 12...0 | ... | 15 16 18 | ... | 10 55 |
| 14...0 | ... | 15 24 21 | ... | 13 14 |
| 16...0 | ... | 15 31 43 | ... | 15 17 N. |

Comet diminishing in brightness.

## *GEOGRAPHICAL NOTES.*

WE regret to learn of the death of Lieutenant Tappenbeck in the Cameroons. He, with Lieutenant Kund, had been doing good work in the Cameroons interior, as they had before done in the Congo region. Lieutenant Kund has returned to Berlin, and has been describing the results of his second journey into the interior. In general, he and his companions followed the same route as on the previous expedition, and were received in quite a friendly way by the natives who had before attacked them. Very interesting observations were made as to the ethnological conditions of the South Cameroons region. A spot was selected for a station, of which the late Lieutenant Tappenbeck was to have been chief. The region is close to the limit of distribution of the Bantus, and there is a considerable variety of ethnological mixtures. Within the limits of the primæval forest, which lies behind the narrow coast stretch, the explorers came upon an almost dwarfish tribe, with yellow skins, hunting in scattered hordes, and building only temporary shelters for themselves. On the plateau, again, the explorers met with a free and friendly population of large, strong, and handsome men, with a well-organized social system. Quite different from the degraded coast people and the decaying forest people, these highland tribes have preserved the original good features of their race; and among them, Lieutenant Kund thinks, the scientific and industrial development of the Cameroons might be carried out.

EVERYONE interested in geographical exploration will be sorry to hear of the death, apparently by assassination, of M. Camille Douls, while on his way across the Sahara towards Timbuctoo. M. Douls was born at Bordes, in Aveyron, in 1864. In 1881 he visited the Antilles and Central America; and four years afterwards he spent some time in Morocco, studying the language and manners of the Arabs. In 1887 he explored the unvisited western regions of the Sahara; and last year he started on the journey which was destined, unhappily, to be his last.

MR. ERNEST FAVENC describes in the August number of the Proceedings of the Royal Geographical Society, the results of a recent exploring journey in West Australia, in the country situated about 24° S. lat. The result of the trip was the discovery of several large tributary rivers of the Ashburton, running through magnificent pastoral country. Mr. Favenc found the physical features of the country different entirely to the conjectural ones placed on some of the maps of West Australia. Still there is a very great scarcity of water, many of the river beds being quite empty. The geological formation of the Ashburton is against the likelihood of any valuable mineral deposits being discovered in the future. There seem, however, to be indications of a gold reef at the head of the Gascoyne.

COLONEL ANTONIO R. P. LABRE, a Brazilian gentleman, has for some time been doing important exploring work in the region between the Beni and Madre de Dios rivers and the Purus. These great South American rivers have been often enough followed along their courses, but no one had attempted to penetrate through the primæval forests that separate their courses. This is what Colonel Labre has done, his leading object being to explore the india-rubber resources of the region. There are many rubber-stations along these rivers, mainly occupied by Bolivians. The principal journey of Colonel Labre was undertaken for the purpose of crossing westward from the india-rubber settlements on the Madre de Dios to the nearest navigable point on the Aquiry tributary of the Purus, and ascertaining if the distance and the nature of the ground presented facilities for the construction of a road, and ultimately of a railway. He ascended the Madeira from the Amazons, and although this is the only route by which the considerable trade to and fro between the Amazons and Bolivia is carried on, it took Colonel Labre, with a large and well-equipped expedition, thirty-four days to accomplish the 161 miles between San Antonio at the foot of the long series of falls, and the town of Villa Bella at the mouth of the Beni. During the overland journey several tribes of Indians were met with, about whom little or nothing is known. The people are mostly Araunas, and seem to have a well-organized social system, with temples and some form of worship. The women, some of them light-coloured, are not allowed to enter the temples. The idols are not of human form, but are geometrical figures made of wood and polished. Several other tribes were met with. The general result of Colonel Labre's expedition was to open up a route of communication between the large towns of the Amazons and the whole of Northern Bolivia, a route which may be extended to Southern Peru by the navigation of the Madre de Dios to the province of Pancastambo and the rich and populous province of Cuzco. Colonel Labre believes that the Purus and its affluents contain about 40,000 indigenes speaking forty or more different languages.

DR. H. MEYER has arrived at Zanzibar for the purpose of making another attempt to ascend to the highest summit of Kilimanjaro. He will afterwards proceed to explore Mount Kenia.

ACCORDING to *Petermann's Mitteilungen*, Prof. A. Wichmann has recently returned to Europe from his journey to the Dutch East Indies. On the little island of Samauw, lying off the coast of Timor, he found numerous mud volcanoes. On the island of Rotti, at the south-west end of Timor, he discovered upon the slopes, in two mud volcanoes, some ammonites and belemnites, the first Jurassic fossils which have been found in this archipelago. Prof. Wichmann crossed from Palos, on the island of Celebes, to the Bay of Tomine, on the east coast. The route lay over a mountain range about 3000 feet high, covered with primæval forests, and uninhabited. These mountains are composed of gneiss, crystalline slate, and granite.

M. H. COUDREAU recently described to the Paris Geographical Society the results of his last expedition to the Tumuc-Humac Mountains (Guiana), which were only very imperfectly explored by the late M. Crevaux. M. Coudreau effected a survey on the scale of 1 : 100,000 of 2500 miles of route, 1625 miles of which lay along river-courses, and the remaining 875 among the mountains. A complete survey was executed of the courses of the Maroni, Oyapock, and Maroni, from their mouths to their sources. M. Coudreau penetrated into the trackless part of the forest, where a passage had to be hewn out. Measurements were made of 150 summits, and the sources of nearly all the water-courses of both slopes of the range were fixed. The climate of these highlands is healthy, the mean temperature being about 72° F. Immense forests cover a large belt of country at the foot of the mountains. From an ethnographical point of view, M. Coudreau's mission has resulted in the careful study of the manners, customs, and dialects of the score or so of Indian tribes inhabiting this region.

M. BORELLI, who for three years has been exploring in the Shoa region and the Galla country, tracing the course of an important River Omo, is convinced that this river falls into Lake Samburu, the Prince Rudolf Lake of Count Teleki; and that therefore the Omo does not belong to the Nile basin, but to an entirely distinct inland lake system, which has no outlet. M. Borelli has brought home hundreds of photographs of the people of the region he has been exploring, and large collections of specimens of the products of the country which will be deposited in the Trocadero.

GENERAL STRELBITZKY has just published a new edition of his work, "The Superficies of the Russian Empire and the Neighbouring States of Asia." He has incorporated in this edition all the new data, accumulated since 1875, relating to the measurement of the superficies of Russia and her Asiatic possessions. Detailed data as to the superficies of interior seas and lakes, islands, and drainage-areas of separate rivers are added; and the writer presents the first trustworthy information as to the superficies of China, Persia, Afghanistan, Bukhara, Khiva, Corea, and Japan. All figures are given in geographical miles, kilometres, and Russian versts.

## AN ATTEMPT TO APPLY TO CHEMISTRY ONE OF THE PRINCIPLES OF NEWTON'S NATURAL PHILOSOPHY.[1]

NATURE, inert to the eyes of the ancients, has been revealed to us as full of life and activity. The conviction that motion pervaded all things, which was first realized with respect to the stellar universe, has now extended to the unseen world of atoms. No sooner had the human understanding denied to the earth a fixed position and launched it along its path in space, than it was sought to fix immovably the sun and the stars. But astronomy has demonstrated that the sun moves with unswerving regularity through the star-set universe at the rate of about 50 kilometres per second. Among the so called fixed stars are now discerned manifold changes and various orders of movement. Light, heat, electricity—like sound—have been proved to be modes of motion; to the realization of this fact modern science is indebted for powers which have been used with such brilliant success, and which have been expounded so clearly at this lecture-table by Faraday and by his successors. As in the imagination of Dante the invisible air became peopled with spiritual beings, so before the eyes of earnest investigators, and especially before those of Clerk Maxwell, the invisible mass of gases became peopled with particles: their rapid movements, their collisions, and impacts became so manifest that it seemed almost possible to count the impacts and determine many of the peculiarities or laws of their collisions. The fact of the existence of these invisible motions may at once be made apparent by demonstrating the difference in the rate of diffusion through porous bodies of the light and rapidly moving atoms of hydrogen and the heavier and more sluggish particles of air. Within the masses of liquid and of solid bodies we have been forced to acknowledge the existence of persistent though limited motion of their ultimate particles, for otherwise it would be impossible to explain, for example, the celebrated experiments of Graham on diffusion through liquid and colloidal substances. If there were, in our times, no belief in the molecular motion in solid bodies, could the famous Spring have hoped to attain any result by mixing carefully dried powders of potash saltpetre, and acetate of soda, in order to produce, by pressure, a chemical reaction between these substances through the interchange of their metals, and have derived, for the conviction of the incredulous, a mixture of two hygroscopic though solid salts—nitrate of soda and acetate of potash?

In these invisible and apparently chaotic movements, reaching from the stars to the minutest atoms, there reigns, however, an harmonious order which is commonly mistaken for complete rest, but which is really a consequence of the conservation of that dynamic equilibrium which was first discerned by the genius of Newton, and which has been traced by his successors in the detailed analysis of the particular consequences of the great generalization,—namely, relative immovability in the midst of universal and active movement.

But the unseen world of chemical changes is closely analogous to the visible world of the heavenly bodies, since our atoms form distinct portions of an invisible world, as planets, satellites, and comets form distinct portions of the astronomer's universe; our atoms may therefore be compared to the solar system, or to the systems of double or of single stars, for example, ammonia ($NH_3$) may be represented in the simplest manner by supposing the sun nitrogen surrounded by its planets of hydrogen; and common salt ($NaCl$) may be looked upon as a double star formed of nitrogen and chlorine. Besides, now that the indestructibility of the elements has been acknowledged, chemical changes cannot otherwise be explained than as changes of motion, and the production by chemical reactions of galvanic currents, of light, of heat, of pressure, or of steam power, demonstrate visibly that the processes of chemical reaction are inevitably connected with enormous though unseen displacements, originating in the movements of atoms in molecules. Astronomers and natural philosophers, in studying the visible motions of the heavenly bodies and of matter on the earth, have understood and have estimated the value of this store of energy. But the chemist has had to pursue a contrary course. Observing in the physical and mechanical phenomena which accompany chemical reactions the quantity of energy manifested by the atoms and molecules, he is constrained to acknowledge that within the molecules there exist atoms in motion, endowed with an energy which, like matter itself, is neither being created nor is capable of being destroyed. Therefore, in chemistry, we must seek dynamic equilibrium not only between the molecules but also in their midst among their component atoms. Many conditions of such equilibrium have been determined, but much remains to be done, and it is not uncommon, even in these days, to find that some chemists forget that there is the possibility of motion in the interior of molecules, and therefore represent them as being in a condition of death-like inactivity.

Chemical combinations take place with so much ease and rapidity, possess so many special characteristics, and are so numerous, that their simplicity and order was for a long time hid from investigators. Sympathy, relationship, all the caprices or all the fancifulness of human intercourse, seemed to have found complete analogies, in chemical combinations, but with this difference, that the characteristics of the material substances—such as silver, for example, or of any other body—remain unchanged in every subdivision from the largest masses to the smallest particles, and consequently their characteristics must be a property of its particles. But the world of heavenly luminaries appeared equally fanciful at man's first acquaintance with it, so much so that the astrologers imagined a connection between the individualities of men and the conjunctions of planets. Thanks to the genius of Lavoisier and of Dalton, man has been able, in the unseen world of chemical combinations, to recognize laws of the same simple order as those which Copernicus and Kepler proved to exist in the planetary universe. Man discovered, and continues every hour to discover, *what* remains unchanged in chemical evolution, and *how* changes take place in combinations of the unchangeable. He has learned to predict, not only what possible combinations may take place, but also the very existence of atoms of unknown elementary bodies, and has besides succeeded in making innumerable practical applications of his knowledge, to the great advantage of his race, and has accomplished this notwithstanding that notions of sympathy and affinity still preserve a strong vitality in science. At present we cannot apply Newton's principles to chemistry, because the soil is only being now prepared. The invisible world of chemical atoms is still waiting for the creator of chemical mechanics. For him our age is collecting a mass of materials, the inductions of well-digested facts, and many-sided inferences similar to those which existed for astronomy and mechanics in the days of Newton. It is well also to remember that Newton devoted much time to chemical experiments, and while considering questions of celestial mechanics, persistently kept in view the mutual action of those infinitely small worlds which are concerned in chemical evolutions. For this reason, and also to maintain the unity of laws, it seems to me that we must, in the first instance, seek to harmonize the various phases of contemporary chemical theories with the immortal principles of the Newtonian natural philosophy, and so hasten the advent of true chemical mechanics. Let the above considerations serve as my justification for the attempt which I propose to make to act as a champion of the universality of the Newtonian principles, which I believe are competent to embrace every phenomenon in the universe, from the rotation of the fixed stars, to the interchanges of chemical atoms.

In the first place, I consider it indispensable to bear in mind that, up to quite recent times, only a one-sided affinity has been recognized in chemical reactions. Thus, for example, from the circumstance that red-hot iron decomposes water with the evolution of hydrogen, it was concluded that oxygen had a greater affinity for iron than for hydrogen. But hydrogen, in presence of red-hot iron scale, appropriates its oxygen, and forms water, whence an exactly opposite conclusion may be formed.

During the last ten years a gradual, scarcely perceptible, but most important change has taken place in the views, and consequently in the researches, of chemists. They have sought everywhere, and have always found systems of conservation or dynamic equilibrium substantially similar to those which natural philosophers have long since discovered in the visible world, and in virtue of which the position of the heavenly bodies in the universe is determined. There, where one-sided affinities only were at first detected, not only secondary or lateral ones have been found, but even those which are diametrically opposite, yet among these, dynamical equilibrium establishes itself, not by excluding one or other of the forces, but regulating them all. So the chemist finds in the flame of the blast-furnace, in the formation of every salt, and, with especial clearness, in double salts, and in the crystallization of solutions, not a fight ending in the victory of one side, as used to be supposed, but the conjunction of forces; the peace of dynamic equilibrium resulting

[1] The Friday evening lecture delivered at the Royal Institution of Great Britain, on May 31, 1889, by Prof. D Mendeleeff, Professor of Chemistry in the University of St. Petersburg.

from the action of many forces and affinities. Carbonaceous matters, for example, burn at the expense of the oxygen of the air, yielding a quantity of heat and forming products of combustion, in which it was thought that the affinities of the oxygen with the combustible elements were satisfied. But it appeared that the heat of combustion was competent to decompose these products, to dissociate the oxygen from the combustible elements; and therefore, to explain combustion fully, it is necessary to take into account the equilibrium between opposite reactions, between those which evolve and those which absorb heat.

In the same way, in the case of the solution of common salt in water, it is necessary to take into account, on the one hand, the formation of compound particles generated by the combination of salt with water, and, on the other, the disintegration or scattering of the new particles formed, as well as of those originally contained. At present we find two currents of thought, apparently antagonistic to each other, dominating the study of solutions: according to the one, solution seems a mere act of building up or association; according to the other, it is only dissociation or disintegration. The truth lies, evidently, between these views; it lies, as I have endeavoured to prove by my investigations into aqueous solutions, in the dynamic equilibrium of particles tending to combine and also to fall asunder. The large majority of chemical reactions which appeared to act victoriously along one line have been proved capable of acting as victoriously even along an exactly opposite line. Elements which utterly decline to combine directly may often be formed into comparatively stable compounds by indirect means, as, for example, in the case of chlorine and carbon; and, consequently, the sympathies and antipathies, which it was thought to transfer from human relations to those of atoms, should be laid aside until the mechanism of chemical relations is explained. Let us remember, however, that chlorine, which does not form with carbon the chloride of carbon, is strongly absorbed, or, as it were, dissolved by carbon, which leads us to suspect incipient chemical action even in an external and purely surface contact, and involuntarily gives rise to conceptions of that unity of the forces of Nature which has been so energetically insisted on by Sir William Grove and formulated in his famous paradox. Grove noticed that platinum, when fused in the oxyhydrogen flame, during which operation water is formed, when allowed to drop into water decomposes the latter and produces the explosive oxyhydrogen mixture. The explanation of this paradox, as of many others which arose during the period of chemical renaissance, has led, in our time, to the promulgation by Henri St. Claire Deville of the conception of dissociation and of equilibrium, and has recalled the teaching of Berthollet, which, notwithstanding its brilliant confirmation by Heinrich Rose and Dr. Gladstone, had not, up to that period, been included in received chemical views.

Chemical equilibrium in general, and dissociation in particular, are now being so fully worked out in detail, and applied in such various ways, that I do not allude to them to develop, but only use them as examples by which to indicate the correctness of a tendency to regard chemical combinations from points of view differing from those expressed by the term hitherto appropriated to define chemical forces—namely, "affinity." Chemical equilibria dissociation, the speed of chemical reactions, thermo-chemistry, spectroscopy, and, more than all, the determination of the influence of masses and the search for a connection between the properties and weights of atoms and molecules; in one word, the vast mass of the most important chemical researches of the present day, clearly indicates the near approach of the time when chemical doctrines will submit fully and completely to the doctrine which was first announced in the "Principia" of Newton.

In order that the application of these principles may bear fruit, it is evidently insufficient to assume that statical equilibrium reigns alone in chemical systems or chemical molecules: it is necessary to grasp the conditions of possible states of dynamical equilibria, and to apply to them kinetic principles. Numerous considerations compel us to renounce the idea of statical equilibrium in molecules, and the recent yet strongly supported appeals to dynamic principles constitute, in my opinion, the foundation of the modern teaching relating to atomicity, or the valency of the elements, which usually forms the basis of investigations into organic or carbon compounds.

This teaching has led to brilliant explanations of very many chemical relations and to cases of isomerism, or the difference in the properties of substances having the same composition. It has been so fruitful in its many applications and in the foreshadowing of remote consequences, especially respecting carbon compounds, that it is impossible to deny its claims to be ranked as a great achievement of chemical science. Its practical application to the synthesis of many substances of the most complicated composition entering into the structure of organized bodies, and to the creation of an unlimited number of carbon compounds, among which the colours derived from coal tar stand prominently forward, surpass the synthetical powers of Nature itself. Yet this teaching, as applied to the structure of carbon compounds, is not on the face of it directly applicable to the investigation of other elements, because in examining the first it is possible to assume that the atoms of carbon have always a definite and equal number of affinities, while in the combinations of other elements this is evidently inadmissible. Thus, for example, an atom of carbon yields only one compound with four atoms of hydrogen and one with four atoms of chlorine in the molecule, while the atoms of chlorine and hydrogen unite only in the proportions of one to one. Simplicity is here evident, and forms a point of departure from which it is easy to move forward with firm and secure tread. Other elements are of a different nature. Phosphorus unites with three and with five atoms of chlorine, and consequently the simplicity and sharpness of the application of structural conceptions are lost. Sulphur unites only with two atoms of hydrogen, but with oxygen it enters into higher orders of combination. The periodic relationship which exists among all the properties of the elements, such, for example, as their ability to enter into various combinations, and their atomic weights, indicate that this variation in atomicity is subject to one perfectly exact and general law, and it is only carbon and its near analogues which constitute cases of permanently preserved atomicity. It is impossible to recognize as constant and fundamental properties of atoms, powers which, in substance, have proved to be variable. But by abandoning the idea of permanence, and of the constant saturation of affinities—that is to say, by acknowledging the possibility of free affinities—many retain a comprehension of the atomicity of the elements "under given conditions"; and on this frail foundation they build up structures composed of chemical molecules, evidently only because the conception of manifold affinities gives, at once, a simple statical method of estimating the composition of the most complicated molecules.

I shall enter neither into details, nor into the various consequences following from these views, nor into the disputes which have sprung up respecting them (and relating especially to the number of isomers possible on the assumption of free affinities), because the foundation or origin of theories of this nature suffers from the radical defect of being in opposition to dynamics. The molecule, as even Laurent expressed himself, is represented as an architectural structure, the style of which is determined by the fundamental arrangement of a few atoms, while the decorative details, which are capable of being varied by the same forces, are formed by the elements entering into the combination. It is on this account that the term "structural" is so appropriate to the contemporary views of the above order, and that the "constructors" seek to justify the tetrahedric, plane, or prismatic disposition of the atoms of carbon in benzole. It is evident that the consideration relates to the statical position of atoms and molecules, and not to their kinetic relations. The atoms of the structural type are like the lifeless pieces on a chess-board: they are endowed but with the voices of living beings, and are not those living beings themselves; acting, indeed, according to laws, yet each possessed of a store of energy, which, in the present state of our knowledge, must be taken into account.

In the days of Haüy, crystals were considered in the same statical and structural light, but modern crystallographers, having become more thoroughly acquainted with their physical properties and their actual formation, have abandoned the earlier views and have made their doctrines dependent on dynamics.

The immediate object of this lecture is to show that, starting with Newton's third law of motion, it is possible to preserve to chemistry all the advantages arising from structural teaching, without being obliged to build up molecules in solid and motionless figures, or to ascribe to atoms definite limited valencies, directions of cohesion, or affinities. The wide extent of the subject obliges me to treat only a small portion of it—namely, of *substitutions*, without specially considering combinations and decompositions—and, even then, limiting myself to the simplest examples, which, however, will throw open prospects embracing all the natural complexity of chemical relations. For this reason, if it should prove possible to form groups similar, for example, to $H_4$ or $CH_6$ as the remnants of molecules $CH_4$ or $C_2H_6$, we shall not pause to consider them, because, as far as we know, they fall asunder into two parts, $H_2 + H_2$ or $CH_4 + H_2$, as soon as they are even temporarily formed, and are capable of separate existence, and therefore can take no part in the elementary act of substitution. With respect to the simplest molecules which we shall select—that is to say, those of which the parts have no separate existence, and therefore cannot appear in substitutions—we shall consider them according to the periodic law, arranging them in direct dependence on the atomic weight of the elements.

Thus, for example, the molecules of the simplest hydrogen compounds—

| HF | $H_2O$ | $H_3N$ | $H_4C$ |
|---|---|---|---|
| Hydrofluoric acid | Water | Ammonia | Methane |

correspond to elements the atomic weights of which decrease consecutively—

$$F = 19, O = 16, N = 14, C = 12.$$

Neither the arithmetical order (1, 2, 3, 4 atoms of hydrogen) nor the total information we possess respecting the elements will permit us to interpolate into this typical series one more additional element; and therefore we have here, for hydrogen compounds, a natural base upon which are built up those simple chemical combinations which we take as typical. But even they are competent to unite with each other, as we see, for instance, in the property which hydrofluoric acid has of forming a hydrate—that is, of combining with water; and the similar attribute of ammonia, resulting in the formation of a caustic alkali, $NH_3H_2O$, or $NH_4OH$.

Having made these indispensable preliminary observations, I may now attack the problem itself, and attempt to explain the so-called structure, or rather construction of molecules—that is to say, their constitution and transformations—without having recourse to the teaching of "structionists," but on Newton's dynamical principles.

Of Newton's three laws of motion, only the third can be applied directly to chemical molecules when regarded as systems of atoms among which it must be supposed that there exist common influences or forces, and resulting compounded relative motions. Chemical reactions of every kind are undoubtedly accomplished by changes in these internal movements, respecting the nature of which nothing is known at present, but the existence of which the mass of evidence collected in modern times forces us to acknowledge as forming part of the common motion of the universe, and as a fact further established by the circumstance that chemical reactions are always characterized by changes of volume or the relations between the atoms or the molecules. Newton's third law, which is applicable to every system, declares that "action is always associated with reaction, and is equal to it." The brevity and conciseness of this axiom was, however, qualified by Newton in a more expanded statement: "The actions of bodies one upon another are always equal, and in opposite directions." This simple fact constitutes the point of departure for explaining dynamic equilibrium—that is to say, systems of conservancy. It is capable of satisfying even the dualists, and of explaining, without additional assumptions, the preservation of those chemical types which Dumas, Laurent, and Gerhardt created unit types, and those views of atomic combinations which the structionists express by atomicity or the valency of the elements, and, in connection with them, the various numbers of affinities. In reality, if a system of atoms or a molecule be given, then in it, according to the third law of Newton, each portion of atoms acts on the remaining portion in the same manner and with the same force as the second set of atoms acts on the first. We infer directly from this consideration that both sets of atoms forming a molecule are not only equivalent with regard to themselves, as they must be according to Dalton's law, but also that they may, if united, replace each other. Let there be a molecule containing atoms A B C, it is clear that, according to Newton's law, the action of A on B C must be equal to the action of B C on A, and if the first action is directed on B C, then the second must be directed on A, and consequently then, where A can exist in dynamic equilibrium, B C may take its place and act in a like manner. In the same way the action of C is equal to the action of A B. In one word every two sets of atoms forming a molecule are equivalent to each other, and may take each other's place in other molecules, or, having the power of balancing each other, the atoms or their complements are endowed with the power of replacing each other. Let us call this consequence of an evident axiom "the principle of substitution," and let us apply it to those typical forms of hydrogen compounds which we have already discussed, and which, on account of their simplicity and regularity, have served as starting-points of chemical argument long before the appearance of the doctrine of structure.

In the type of hydrofluoric acid, HF, or in systems of double stars, are included a multitude of the simplest molecules. It will be sufficient for our purpose to recall a few: for example, the molecules of chlorine, $Cl_2$, and of hydrogen, $H_2$, and hydrochloric acid, HCl, which is familiar to all in aqueous solution as spirit of salt, and which has many points of resemblance with HF, $HB_2$, HI. In these cases division into two parts can only be made in one way, and therefore the principle of substitution renders it probable that exchanges between the chlorine and the hydrogen can take place, if they are competent to unite with each other. There was a time when no chemist would even admit the idea of any such action; it was then thought that the power of combination indicated a polar difference of the molecules in combination, and this thought set aside all idea of the substitution of one component element by another.

Thanks to the observations and experiments of Dumas and Laurent fifty years ago, such fallacies were dispelled, and in this manner this same principle of substitution was exhibited. Chlorine and bromine, acting on many hydrogen compounds, occupy immediately the place of their hydrogen, and the displaced hydrogen, with another atom of chlorine or bromine, forms hydrochloric acid or bromide of hydrogen. This takes place in all typical hydrogen compounds. Thus chlorine acts on this principle on gaseous hydrogen—reaction, under the influence of light, resulting in the formation of hydrochloric acid. Chlorine, acting on the alkalies, constituted similarly to water, and even on water itself—only, however, under the influence of light, and only partially because of the instability of HClO—forms, by this principle, bleaching salts, which are the same as the alkalies, but with their hydrogen replaced by chlorine. In ammonia and in methane, chlorine can also replace the hydrogen. From ammonia is formed in this manner the so-called chloride of nitrogen, $NCl_3$, which decomposes very readily with violent explosion on account of the evolved gases, and falls asunder as chlorine and nitrogen. Out of marsh gas, or methane, $CH_4$, may be obtained consecutively, by this method, every possible substitution, of which chloroform, $CHCl_3$, is the best known, and chloro-carbonic acid, $CCl_4$, the most instructive. But by virtue of the fact that chlorine and bromine act in the manner shown on the simplest typical hydrogen compounds, their action on the more complicated ones may be assumed to be the same. This can be easily demonstrated. The hydrogen of benzole, $C_6H_6$, reacts feebly under the influence of light on liquid bromine, but Gustavson has shown that the addition of the smallest quantity of metallic aluminium causes energetic action, and the evolution of large volumes of bromide of hydrogen.

If we pass on to the second typical hydrogen compound—that is to say, water—its molecule, HOH, may be split up in two ways: either into an atom of hydrogen and a molecule of oxide of hydrogen, HO, or into oxygen, O, and two atoms of hydrogen, H; and therefore, according to the principle of substitution, it is evident that one atom of hydrogen can exchange with oxide of hydrogen, HO, and two atoms of hydrogen, H, with one atom of oxygen, O.

Both these forms of substitution will constitute methods of oxidation—that is to say, of the entrance of oxygen into the compound—a reaction which is so common in Nature as well as in the arts, taking place at the expense of the oxygen of the air or by the aid of various oxidizing substances or bodies which part easily with their oxygen. There is no occasion to reckon up the unlimited number of cases of such oxidizing reactions. It is sufficient to state that, in the first of these, oxygen is directly transferred, and the position, the chemical function, which hydrogen originally occupied is, after the substitution, occupied by the hydroxyl. Thus ammonia, $NH_3$, yields hydroxylamine, $NH_2(OH)$, a substance which retains many of the properties of ammonia.

Methane and a number of other hydrocarbons yield, by substitution of the hydrogen by its oxide, methylic, $CH_3(OH)$, and other alcohols. The substitution of one atom of oxygen for two atoms of hydrogen is equally common with hydrogen compounds. By this means alcoholic liquids containing ethyl alcohol, or spirits of wine, $C_2H_5(OH)$, are oxidized till they become vinegar or acetic acid, $C_2H_3O(OH)$. In the same way caustic ammonia, or the combination of ammonia with water, $NH_3H_2O$, or $NH_4(OH)$, which contains a great deal of hydrogen, by oxidation exchanges four atoms of hydrogen for two atoms of oxygen, and becomes converted into nitric acid, $NO_2(OH)$. This process of conversion of ammonia salts into saltpetre goes on in the fields every summer, and with especial rapidity in tropical countries. The method by which this is accomplished, though complex, though involving the agency of all-permeating micro-organisms, is, in substance, the same as that by which alcohol is converted into acetic acid, or glycol, $C_2H_4(OH)_2$ into oxalic acid, if we view the process of oxidation in the light of the Newtonian principles.

But while speaking of the application of the principle of substitution to water, we need not multiply instances, but must turn our attention to two special circumstances which are closely connected with the very mechanism of substitutions.

In the first place, the replacement of two atoms of hydrogen by one atom of oxygen may take place in two ways, because the hydrogen molecule is composed of two atoms, and therefore, under the influence of oxygen, the molecule forming water may separate before the oxygen has time to take its place. It is for this reason that we find, during the conversion of alcohol into acetic acid, that there is an interval during which is formed aldehyde, $C_2H_4O$, which, as its very name implies, is "alcohol dehydrogenatum," or alcohol deprived of hydrogen. Hence aldehyde combined with hydrogen yields alcohol, and, united to oxygen, acetic acid.

For the same reason there should be, and there actually are, intermediate products between ammonia and nitric acid, $NO_2(HO)$, containing either less hydrogen than ammonia, less oxygen than nitric acid, or less water than caustic ammonia. Accordingly we find, among the products of the de-oxidization of nitric acid and the oxidization of ammonia, not only hydroxylamine, but also nitrous oxide, nitrous and nitric anhydrides. Thus, the production of nitrous acid results from the removal of two atoms of hydrogen from caustic ammonia and the substitution of the oxygen for the hydrogen, $NO(OH)$; or by the substitution, in ammonia, of three atoms of hydrogen by hydroxyl, $N(OH)_3$, and by the removal of water; $N(OH)_3 - H_2O = NO(OH)$. The peculiarities and properties of nitrous acid, as, for instance, its action on ammonia and its conversion, by oxidation, into nitric acid, are thus clearly revealed.

On the other hand, in speaking of the principle of substitution as applied to water, it is necessary to observe that hydrogen and hydroxyl, H and OH, are not only competent to unite, but also to form combinations with themselves, and thus become $H_2$ and $H_2O_2$; and such are hydrogen and the peroxide thereof. In general, if a molecule AB exists, then molecules AA and BB can exist also. A direct reaction of this kind does not, however, take place in water, therefore undoubtedly, at the moment of formation hydrogen reacts on the peroxide of hydrogen, as we can show at once by experiment; and further, because the peroxide of hydrogen, $H_2O_2$, exhibits a structure containing a molecule of hydrogen, $H_2$, and one of oxygen, $O_2$, either of which is capable of separate existence. The fact, however, may now be taken as thoroughly established, that, at the moment of combustion of hydrogen or of the hydrogen compounds, peroxide of hydrogen is always formed, and not only so, but in all probability its formation invariably precedes the formation of water. This was to be expected as a consequence of the law of Avogadro and Gerhardt, which leads us to expect this sequence in the case of equal interactions of volumes of vapours and gases; and in the peroxide of hydrogen we actually have such equal volumes of the elementary gases.

The instability of peroxide of hydrogen—that is to say, the ease with which it decomposes into water and oxygen, even at the mere contact of porous bodies—accounts for the circumstance that it does not form a permanent product of combustion, and is not produced during the decomposition of water. I may mention this additional consideration that, with respect to the peroxide of hydrogen, we may look for its effecting still further substitutions of hydrogen by means of which we may expect to obtain still more highly oxidized water-compounds, such as $H_2O_3$ and $H_2O_4$. These, Schönbein and Bunsen have long been seeking, and Berthelot is investigating them at this moment. It is probable, however, that the reaction will stop at the last compound, because we find that in a number of cases the addition of four atoms of oxygen seems to form a limit. Thus, $OsO_4$, $KClO_4$, $KMnO_4$, $K_2SO_4$, $Na_3PO_4$, and such like, represent the highest grades of oxidation.[1]

As for the last forty years, from the times of Berzelius, Dumas, Liebig, Gerhardt, Williamson, Frankland, Kolbe, Kekulé, and Butlerow, most theoretical generalizations have centred round organic or carbon compounds, so we will, for the sake of brevity, leave out the discussion of ammonia derivatives, notwithstanding their simplicity in respect to the doctrine of substitutions; we will dwell more especially on its application to carbon compounds, starting from methane, $CH_4$, as the simplest of the hydrocarbons, containing in its molecule one atom of carbon. According to the principles enumerated, we may derive from $CH_4$ every combination of the form $CH_3X$, $CH_2X_2$, $CHX_3$, and $CX_4$, in which X is an element, or radical, equivalent to hydrogen—that is to say, competent to take its place or to combine with it. Such are the chlorine substitutes mentioned already, such is wood-spirit, $CH_3(OH)$, in which X is represented by the residue of water, and such are numerous other carbon derivatives. If we continue, with the aid of hydroxyl, further substitutions of the hydrogen of methane, we shall obtain successively $CH_2(OH)_2$, $CH(OH)_3$, and $C(OH)_4$. But if, in proceeding thus, we bear in mind that $CH_2(OH)_2$ contains two hydroxyls in the same form as peroxide of hydrogen, $H_2O_2$ or $(OH)_2$, contains them—and, moreover, not only in one molecule, but together, attached to one and the same atom of carbon—so here we must look for the same decomposition as that which we find in peroxide of hydrogen, and accompanied also by the formation of water as an independently existing molecule; therefore $CH_2(OH)_2$ should yield, as it actually does, immediately water and the oxide of methylene, $CH_2O$, which is methane with oxygen substituted for two atoms of hydrogen. Exactly in the same manner out of $CH(OH)_3$ are formed water and formic acid, $CHO(OH)$, and out of $C(OH)_4$ is produced water and carbonic acid, or directly carbonic anhydride, $CO_2$, which will therefore be nothing else than methane with the double replacement of pairs of hydrogen by oxygen. As nothing leads to the supposition that the four atoms of hydrogen in methane differ one from the other, so it does not matter by what means we obtain any one of the combinations indicated—they will be identical; that is to say, there will be no case of actual isomerism, although there may easily be such cases of isomerism as have been distinguished by the term metamerism.

Formic acid, for example, has two atoms of hydrogen, one attached to the carbon left from the methane, and the other attached to the oxygen which has entered in the form of hydroxyl, and if one of them be replaced by some substance, X, it is evident that we shall obtain bodies of the same composition, but of different construction, or of dfferent orders of movement among the molecules, and therefore endowed with other properties and reactions. If X be methyl, $CH_3$—that is to say, a group capable of replacing hydrogen because it is actually contained with hydrogen in methane itself—then by substituting this group for the original hydrogen, we obtain acetic acid, $CCH_3O(OH)$, out of formic, and by substitution of the hydrogen in its oxide or hydroxyl, we obtain methyl formiate, $CHO(OCH_3)$. These bodies differ so much from each other physically and chemically that, at first sight, it is hardly possible to admit that they contain the same atoms in identically the same proportions. Acetic acid, for example, boils at a higher temperature than water, and has a higher specific gravity than it, while its metamer, formo-methylic ether, is lighter than water, and boils at 30°—that is to say, it evaporates very easily.

Let us now turn to carbon compounds containing two atoms

[1] Because more than four atoms of hydrogen never unite with one atom of the elements, and because the hydrogen compounds (*e.g.* $HCl$, $H_2S$, $H_3P$, $H_4Si$) always form their highest oxides with four atoms of oxygen, and as the highest forms of oxides ($OSO_4RO_4$) also contain four of oxygen, and eight groups of the periodic system, corresponding to the highest basic oxides $R_2O$, $RO$, $R_2O_3$, $RO_2$, $R_2O_5$, $RO_3$, $R_2O_7$, and $RO_4$, imply the above relationship, and because of the nearest analogues among the elements—such as Mg, Zn, Cd, and Hg; or Cr, Mo, W, and U; or Si, Ge, Sn, and Pt; or F, Cl, Br, and J, and so forth—not more than four are known, it seems to me that in these relationships there lies a deep interest and meaning with regard to chemical mechanics. But because, to my imagination, the idea of unity of design in Nature, either acting in complex celestial systems or among chemical molecules, is very attractive, especially because the atomic teaching at once acquires its true meaning, I will recall the following facts relating to the solar system. There are eight major planets, of which the four inner ones are not only separated from the four outer by asteroids, but differ from them in many respects, as, for example, in the smallness of their diameters and their greater density. Saturn with his ring has eight satellites, Jupiter and Uranus have each four. It is evident that in the solar systems also we meet with these higher numbers, four and eight, which appear in the combination of chemical molecules.

of carbon to the molecule, as in acetic acid, and proceed to evolve them from methane by the principle of substitution. This principle declares at once that methane can only be split up in the four following ways :—

(1) Into a group $CH_3$ equivalent with H. Let us call changes of this nature methylation.

(2) Into a group $CH_2$ and $H_2$. We will call this order of substitutions methylenation.

(3) Into CH and $H_3$, which commutations we will call acetylenation.

(4) Into C and $H_4$, which may be called carbonization.

It is evident that hydrocarbon compounds containing two atoms of carbon can only proceed from methane, $CH_4$, which contains four atoms of hydrogen by the first three methods of substitution : carbonizing would yield free carbon if it could take place directly, and if the molecule of free carbon—which is in reality very complex, that is to say, strongly polyatomic, as I have long since been proving by various means—could contain only $C_2$ like the molecules $O_2$, $H_2$, $N_2$, and so on.

By methylation, we should evidently obtain from marsh gas, ethane, $CH_3CH_3 = C_2H_6$.

By methylenation, that is, by substituting group $CH_2$ for $H_2$, methane forms ethylene, $CH_2CH_2 = C_2H_4$.

By acetylenation, that is, by substituting three atoms of hydrogen, $H_3$, in methane, by the remnant CH, we get acetylene $CHCH = C_2H_2$.

If we have applied the principles of Newton correctly, there should not be any other hydrocarbons containing two atoms of carbon in the molecule. All these combinations have long been known, and in each of them we can not only produce those substitutions of which an example has been given in the case of methane, but also all the phases of other substitutions, as we shall find from a few more instances, by the aid of which I trust that I shall be able to show the great complexity of those derivatives which, on the principle of substitution, can be obtained from each hydrocarbon. Let us content ourselves with the case of ethane, $CH_3CH_3$, and the substitution of the hydrogen by hydroxyl. The following are the possible changes : —

(1) $CH_3CH_2(OH)$ : this is nothing more than spirit of wine, or ethyl alcohol, $C_2H_5(OH)$, or $C_2H_6O$.

(2) $CH_2(OH)CH_2(OH)$ : this is the glycol of Wurtz, which has shed so much light on the history of alcohol. Its isomer may be $CH_3CH(OH)_2$, but as we have seen in the case of $CH(OH)_2$, it decomposes, giving off water, and forming aldehyde, $CH_3CHO$, a body capable of yielding alcohol by uniting with hydrogen and of yielding acetic acid by uniting with oxygen.

If glycol $CH_2(OH)CH_2(OH)$ loses its water, it may be seen at once that it will not now yield aldehyde, $CH_3CHO$, but its isomer, $\underset{O}{CH_2CH_2}$, the oxide of ethylene. I have here indicated in a special manner the oxygen which has taken the place of two atoms of the hydrogen of ethane taken from different atoms of the carbon.

(3) $CH_3C(OH)_3$ decomposed as $CH(OH)_3$, forming water and acetic acid, $OH_3CO(OH)$. It is evident that this acid is nothing else than formic acid, $CHO(OH)$, with its hydrogen replaced by methyl. Without examining further the vast number of possible derivatives, I will direct your attention to the circumstance that in dissolving acetic acid in water we obtain the maximum contraction, and the greatest viscosity when to the molecule $CH_3CO(OH)$ is added a molecule of water, which is the proportion which would form the hydrate $CH_3C(OH)_3$. It is probable that the doubling of the molecule of acetic acid at temperatures approaching its boiling-point has some connection with this power of uniting with one molecule of water.

(4) $CH^2(OH)C(OH)^3$ is evidently alcoholic acid, and indeed this compound, after losing water, answers to glycolic acid, $CH_2(OH)CO(OH)$. Without investigating all the possible isomers, we will note only that the hydrate $CH(OH)_2CH(OH)_2$ has the same composition as $CH_2(OH)C(OH)_3$, and although corresponding to glycol, and being a symmetrical substance, it becomes, on parting with its water, aldehyde of oxalic acid, or the glyoxal of Debus, $CHOCHO$.

(5) $CH(OH)_2C(OH_3)$, from the tendency of all the preceding, coresponds to glyoxylic acid, aldehyde acid, $CHOCO(OH)$, because the group $CO(OH)$, or carboxyl, enters into the compositions of organic acids, and the group CHO defines the aldehyde function.

(6) $C(OH)_3C(OH)_3$, through the loss of $2H_2O$, yields the bibasic oxalic acid $CO(OH)CO(OH)$, which generally crystallizes with $2H_2O$, following thus the normal type of hydration characteristic of ethane.[1]

Thus, by applying the principle of substitution, we can, in the simplest manner, derive not only every kind of hydrocarbon compound, such as the alcohols, the aldehyde alcohols, aldehydes, alcohol acids, and the acids, but also combinations analogous to hydrated crystals which usually are disregarded.

But even those unsaturated substances, of which ethylene, $CH_2CH_2$, and acetylene, CHCH, are types, may be evolved with equal simplicity. With respect to the phenomena of isomerism, there are many possibilities among the hydrocarbon compounds containing two atoms of carbon, and without going into details it will be sufficient to indicate that the following formulæ, though not identical, will be isomeric substantially among themselves : $CH_3CHX_2$ and $CH_2XCH_2X$, although both contain $C_2H_4X_2$, or $CH_3CX_3$ and $CHXCHX$, although both contain $C_2H_2X_2$, if by X we indicate chlorine or generally an element capable of replacing one atom of hydrogen, or capable of uniting with it. To isomerism of this kind belongs the case of aldehyde and the oxide of ethylene, to which we have already referred, because both have the composition $C_2H_4O$.

What I have said appears to me sufficient to show that the principle of substitution adequately explains the composition, the isomerism and all the diversity of combination of the hydrocarbons, and I shall limit the further development of these views to preparing a complete list of every possible hydrocarbon compound containing three atoms of carbon in the molecule. There are eight in all, of which only five are known at present.[2]

Among those possible for $C_3H_6$ there should be two isomers, propylene and trimethylene, and they are both already known. For $C_3H_4$ there should be three isomers : allylene and allene are known, but the third has not yet been discovered ; and for $C_3H_2$ there should be two isomers, though neither of them are known as yet. Their composition and structure is easily deduced from ethane, ethylene, and acetylene, by methylation, methylenation, by acetylenation and by carbonization.

(1) $C_3H_8 = CH_3CH_2CH_3$ out of $CH_3CH_3$ by methylation. This hydrocarbon is named propane.

(2) $C_3H_6 = CH_3CHCH_2$ out of $CH_3CH_3$ by methylenation. This substance is propylene.

(3) $C_3H_6 = CH_2CH_2CH_2$ out of $CH_3CH_3$ by methylenation. This substance is trimethylene.

(4) $C_3H_4 = CH_3CCH$ out of $CH_3CH_3$ by acetylenation or from CHCH by methylation. This hydrocarbon is named allylene.

(5) $C_3H_4 = \underset{CH_2}{CHCH}$ out of $CH_3CH_3$ by acetylenation, or from $CH_2CH_2$ by methylenation, because $\underset{CH}{CH_2CH} = \underset{CH_2}{CHCH}$. This body is as yet unknown.

(6) $C_3H_4 = CH_2CCH_2$ out of $CH_2CH_2$ by methylenation. This hydrocarbon is named allene, or iso-allylene.

(7) $C_3H_2 = \underset{C}{CHCH}$ out of $CH_3H_3$ by symmetrical carbonization, or out of $CH_2CH_2$ by acetylenation. This compound is unknown.

(8) $C_3H_2 = \underset{CH_2}{CC}$ out of $CH_3CH_3$ by carbonization, or out of CHCH by methylenation. This compound is unknown.

[1] One more isomer, $CH_2CH(OH)$, is possible, that is secondary vinyl alcohol, which is related to ethylene, $CH_2CH_2$, but derived by the principle of substitution from $CH_4$. Other isomers of the composition $C_2H_4O$, such, for example, as $CHCH_3(OH)$, are impossible, because it would correspond to the hydrocarbon $CHCH_3 = C_2H_4$, which is isomeric with ethylene, and it cannot be derived from methane. If such an isomer existed, it would be derived from $CH_2$, but such products are up to the present unknown. In such cases the insufficiency of the points of departure of the statical structural teaching is shown. It first admits constant atomicity, and then rejects it, the facts serving to establish either one or the other view ; and therefore, it seems to me that we must come to the conclusion that the structural method of reasoning, having done a service to science, has outlived the age, and must be regenerated, as, in their time, was the teaching of the electro-chemists, the radicalists, and the adherents of the doctrine of types. As we cannot now lean on the views above stated, it is time to abandon the structural theory. They will all be united in chemical mechanics, and the principle of substitution must be looked upon only as a preparation for the coming epoch in chemistry, where such cases as the isomerism of fumaric and maleic acids, when explained dynamically, as proposed by Le Bel and Van 't Hoff, may yield points of departure.

[2] Conceding variable atomicity, the structurists must expect an incomparably larger number of isomers, and they cannot now decline to acknowledge the change of atomicity, were it only for the examples HgCl and $HgCl_2$, CO and $CO_2$, $PCl_3$ and $PCl_5$.

If we bear in mind that for each hydrocarbon serving as a type in the above tables there are a number of corresponding derivatives, and that every compound obtained may, by further methylation, methylenation, acetylenation, and carbonization, produce new hydrocarbons, and these may be followed by a numerous suite of derivatives and an immense number of isomeric bodies, it is possible to understand the limitless number of carbon compounds, although they all have the one substance, methane, for their origin. The number of substances is so enormous, that it is no longer a question of enlarging the possibilities of discovery, but rather of finding some means of testing them, analogous to the well-known two which for a long time have served as gauges for all carbon compounds.

I refer to the law of even numbers and to that of limits, the first enunciated by Gerhardt forty years ago, with respect to hydrocarbons—namely, that their molecules always contain an even number of atoms of hydrogen. But by the method which I have used of deriving all the hydrocarbons from methane, $CH_4$, this law may be deduced as a direct consequence of the principle of substitutions. Accordingly, in methylation, $CH_3$ takes the place of H, and therefore $CH_2$ is added. In methylenation the number of atoms of hydrogen remains unchanged, and at each acetylenation it is reduced by two, and in carbonization by four atoms—that is to say, an even number of atoms of hydrogen is always added or removed. And because the fundamental hydrocarbon, methane, $CH_4$, contains an even number of atoms of hydrogen, therefore all its derivative hydrocarbons will also contain even numbers of hydrogen, and this constitutes the law of even numbered parts.

The principle of substitutions explains with equal simplicity the conception of limiting compositions of hydrocarbons, $C_nH_{2n+2}$, which I derived, in 1861,[1] in an empirical manner from accumulated materials available at that time, and on the basis of the limits to combinations worked out by Dr. Frankland for other elements.

Of all the various substitutions the highest proportion of hydrogen is yielded by methylation, because in that operation alone does the quantity of hydrogen increase; therefore, taking methane as a point of departure, if we imagine methylation effected $(n-1)$ times we obtain hydrocarbon compounds containing [the highest quantities of hydrogen. It is evident that they will contain

$$CH_4 + (n-1)\ CH_2, \text{ or } C_nH_{2n+2},$$

because methylation leads to the addition of $CH_2$ to the compound.

It will thus be seen that by the principle of substitution—that is to say, by the third law of Newton—we are able to deduce, in the simplest manner, not only the individual composition, the somerism, and relations of substances, but also the general laws which govern their most complex combinations, without having recourse either to statical constructions, to the definition of atomicities, to the exclusion of free affinities, or to the recognition of those single, double, or treble ties which are so indispensable to structurists in the explanation of the composition and construction of hydrocarbon compounds. And yet, by the application of the dynamic principles of Newton, we can attain to that chief and fundamental object—the comprehension of isomerism in hydrocarbon compounds, and the forecasting of the existence of combinations as yet unknown, by which the edifice raised by structural teaching is strengthened and supported. Besides, and I count this for a circumstance of special importance, the process which I advocate will make no difference in those special cases which have been already so well worked out, such as, for example, the isomerism of the hydrocarbons and alcohols, even to the extent of not interfering with the nomenclature which has been adopted, and the structural system will retain all the glory of having worked up, in a thoroughly scientific manner, the store of information which Gerhardt had accumulated about the middle of the fifties, and the still higher glory of establishing the rational synthesis of organic substances. Nothing will be lost to the structural doctrine, except its statical origin; and as soon as it will embrace the dynamic principles of Newton, and suffer itself to be guided by them, I believe that we shall attain, for chemistry, that unity of principle which is now wanting. Many an adept will be attracted to that brilliant and fascinating enterprise, the penetration into the unseen world of the kinetic relations of atoms, to the study of which the last twenty-five years have contributed so much labour and such high inventive faculties.

D'Alembert found in mechanics, that if inertia be taken to represent force, dyamic equations may be applied to statical questions which are thereby rendered more simple and more easily understood.

The structural doctrine in chemistry has unconsciously followed the same course, and therefore its terms are easily adopted; they may retain their present forms provided that a truly dynamical—that is to say, Newtonian—meaning be ascribed to them.

Before finishing my task and demonstrating the possibility of adapting structural doctrines to the dynamics of Newton, I consider it indispensable to touch on one question which naturally arises, and which I have heard discussed more than once. If bromine, the atom of which is eighty times heavier than that of hydrogen, takes the place of hydrogen, it would seem that the whole system of dynamic equilibrium must be destroyed.

Without entering into the minute analysis of this question, I think it will be sufficient to examine it by the light of two well-known phenomena, one of which will be found in the department of chemistry, and the other in that of celestial mechanics, and both will serve to demonstrate the existence of that unity in the plan of creation, which is a consequence of the Newtonian doctrines. Experiments demonstrate that when a heavy element is substituted for a light one, in a chemical compound—an atom of magnesium in the oxide of that metal, for example, for mercury, the atom of which is 8⅓ times heavier—the chief chemical characteristics or properties are generally though not always preserved.

The substitution of silver for hydrogen, than which it is 108 times heavier, does not affect all the properties of the substance, though it does some. Therefore chemical substitutions of this kind, the substitution of light for heavy atoms, need not necessarily entail changes in the original equilibrium; and this point is still further elucidated by the consideration that the periodic law indicates the degree of influence of an increment of weight in the atom as affecting the possible equilibria; and also what degree of increase in the weight of the atoms reproduces some, though not all, the properties of the substance.

This tendency to repetition, these periods, may be likened to those annual or diurnal periods with which we are so familiar on the earth. Days and years follow each other; but, as they do so, many things change; and in like manner chemical evolutions, changes in the masses of the elements, permit of much remaining undisturbed, though many properties undergo alteration. The system is maintained according to the laws of conservation in Nature, but the motions are altered in consequence of the change of parts.

Next, let us take an astronomical case, such for example as the earth and the moon, and let us imagine that the mass of the latter is constantly increasing. The question is, what will then occur? The path of the moon in space is a wave-line similar to that which geometricians have named epicycloidal, or the locus of a point in a circle rolling round another circle. But in consequence of the influence of the moon, it is evident that the path of the earth itself cannot be a geometric ellipse, even supposing the sun to be immovably fixed; it must be an epicycloidal curve, though not very far removed from the true ellipse, that is to say, it will be impressed with but faint undulations. It is only the common centre of gravity of the earth and the moon which describes a true ellipse round the sun. If the moon were to increase, the relative undulations of the earth's path would increase in amplitude, those of the moon would also change, and when the mass of the moon had increased to an equality with that of the earth, the path would consist of epicycloidal curves crossing each other, and having opposite phases. But a similar relation exists between the sun and the earth, because the former is also moving in space. We may apply these views to the world of atoms, and suppose that, in their movements, when heavy ones take the place of those that are lighter, similar changes take place provided that the system or the molecule is preserved throughout the change.

It seems probable that in the heavenly systems, during incalculable astronomical periods, changes have taken place and are still going on similar to those which pass rapidly before our eyes during the chemical reaction of molecules, and the progress of molecular mechanics may—we hope will—in course of time, permit us to explain those changes in the stellar world which have more than once been noticed by astronomers, and which are

[1] "Essai d'une théorie sur les limites des combinaisons organiques," par D. Mendeleeff, 2/11 août 1861, *Bulletin de l'Académie i. d. Sc. de St.-Pétersbourg*, t. v.

now so carefully studied. A coming Newton will discover the laws of these changes. Those laws, when applied to chemistry, may exhibit peculiarities, but these will certainly be mere variations on the grand harmonious theme which reigns in Nature. The discovery of the laws which produce this harmony in chemical evolutions will only be possible, it seems to me, under the banner of Newtonian dynamics which has so long waved over the domains of mechanics, astronomy, and physics. In calling chemists to take their stand under its peaceful and catholic shadow, I imagine that I am aiding in establishing that scientific union which the managers of the Royal Institution wish to effect, who have shown their desire to do so by the flattering invitation which has given me—a Russian—the opportunity of laying before the countrymen of Newton an attempt to apply to chemistry one of his immortal principles.

## *BABYLONIAN ASTRONOMY.*[1]

### IV.

THE nightly motion of the stars from east to west appears to have been the only one known to the Babylonian astronomers. The inclination of the equator on the ecliptic brought, however, a few of the austral stars over the horizon at certain times of the year for a short period, and in a few cases, as in that of the star *Sukudu* (Sirius), these stars were used to determine certain periods or festivals. The complicated motion of the planets never was known to them, and the planets were accordingly regarded as evil spirits which disturbed the harmony of Nature. A similar view is taken in the Zend-Avesta. After a cosmical year of 360,000 ordinary years, the series of heavenly and consequently terrestrial events was to begin again.

While the Semitic religion had emerged from tribal monotheism, the Akkadians followed a sect professing Mazdeism—that is, a religion admitting two principles, one good and one bad; but they thought that, as the good gods would not hurt them, it was wise to propitiate the bad ones, and propitiation easily led to worship. That is how the seven planets, the disturbers of heavenly harmony, became their chief deities. For the same reason all disturbing causes, apparent or real, were subjects of their special attention, pestilence, thunder, comets, &c. Eclipses (which they could not predict) were at first also of bad omen, but by a curious reversion they became happy signs.

The ignorance of the Babylonians with regard to astronomy might have been gathered from the statements of classical authors, if they had been examined with an unprejudiced mind. Diodorus Siculus says positively that their notions about astronomy, fixed at an early date, never changed, and that they could not predict the solar eclipses. We also know from a fragment of Berosus, preserved by Vitruvius, that the Babylonians believed the moon to be a globe half incandescent and half dark, the lunar phases and eclipses being produced by its own motion. The errors and contradictions of the Greek and Latin authors, which misled us also, came from the fact that they borrowed their information from the Alexandrian astronomers, who, they thought, derived their science from Babylon. This was true, indeed, but only to a very small extent, as we shall see.

When, after the conquest of Alexander, the Greeks established themselves in Babylon, they imported with them all their scientific knowledge. The Babylonians, who had to learn Greek, soon discovered the accuracy of their new masters in science, and, exactly as did the Chinese astronomers after the settlement of the Jesuits in China, adopted the discoveries of the West.

This is put beyond doubt by the tablets of this period, the Seleucidian, which give tables of the motions of the moon and planets, and mention solar and lunar eclipses without any omens. The Seleucidian astronomers, wishing to use the older observations, made search for old records and tabulated them; these tablets are of the highest interest from the astronomical point of view. The British Museum possesses, for instance, a tablet, written 100 years B.C., giving the list of nineteen lunar cycles of eighteen years—that is, a table combining the Metonic cycle with the *saros*. This *saros*, or cycle of the lunar eclipses, must have been discovered after the settlement of the Greeks; it was called the "king" (*sar* in Babylonian, hence *saros* in Greek) just as the Metonic cycle was called "golden."

The first care of these astronomical innovators was, no doubt, to reform the very defective calendar of former times. They also divided the ecliptic into twelve parts, corresponding to the months, and chose twelve cuneiform signs to represent in their tablets the twelve zodiacal constellations. They then devised the Græco-Babylonian calendar, whence was derived the Jewish one of the time of the Maccabees.

This reform was not made, however, without causing a certain confusion in the star nomenclature, and even in the calendar itself; for, as the older Babylonians used to connect the various parts of the year with the stars or constellations according to their acronic rising, there was a certain hesitation in the choice made by the reformers. Probably this was what caused the parallel use of two calendars, one beginning with Nisan and the other with Tisrit. This hesitation has also left traces in the signs chosen to designate the zodiacal constellations; for instance, the sign representing the month Tisrit in older Babylonian was used to represent the constellation connected with the month Nisan.

It was from this new focus of astronomical science that the Alexandrian astronomers borrowed much of their information. Unfortunately, the old Babylonian superstitions had a most injurious influence on the rising Alexandrian astronomy. Jewish, Syrian, and Babylonian emigrants, fleeing from the Seleucidian tyranny, flocked to Egypt, bringing with them their superstitions and love for allegories. The Alexandrian astronomers accepted with the Babylonian nomenclature all the ideas of influences attributed to planets and stars, and, being able to predict conjunctions, tried to predict events supposed to be due to star influences. Astrology was then born, for astrology, it must be remembered, requires an accurate knowledge of the motions of stars and planets.

In conclusion, it may be said that we owe very little to the old Babylonian astronomers, and if the astronomical work of Berosus had been preserved, it would have given no scientific information, but only long lists of omens drawn from the rising and conjunctions of stars and planets, and also from their colour and other accidental aspects. The loss of such a work is not much to be regretted.

[1] Abstract of the fourth lecture delivered by Mr. G. Bertin at the British Museum. Continued from p. 285.

## BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Annuario dell' Instituto Cartografico Italiano, 1884 (Roma).—Algerian Hints for Tourists: C. E. Flower (Stanford).—Mason Science College, Birmingham; Syllabus of Day Classes, Session 1889-90.—The Visitation of Pallas's Sand-Grouse to Scotland in 1888: Rev. H. R. Macpherson (Porter).—Quarterly Journal of Microscopical Science, July (Churchill).—Madras Journal of Literature and Science for the Session 1888-89 (Madras).—Journal of the Anthropological Institute, August (Trübner).—Journal of the Chemical Society, August (Gurney and Jackson).—Archives Italiennes de Biologie, tome xii., fasc. 1, 2 (Turin, Loescher).

## CONTENTS.