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THURSDAY, AUGUST 27, 1874

FIFTH REPORT OF THE SCIENCE COMMISSION

THE Fifth Report of the Royal Commission on Scientific Instruction and the Advancement of Science, just issued, is a comparatively short one; but to many it will possess an unusual amount of interest, as showing how far private effort may be relied upon to supply the vast deficiency which at present exists in the means for affording a higher education accessible to all classes.

The Report is concerned with five institutions, each the result of private effort, and each having done much in its own way to raise the standard of the higher education, to place it within the reach of a wider circle, and to bring the physical and natural sciences to the front as indispensable branches of knowledge and an invaluable means of culture, without which all education must be radically incomplete. These institutions are—the two metropolitan Colleges (viz., University and King's Colleges), the Owens College, the Newcastle College of Physical Science, and the Catholic University of Ireland.

The Report gives an account of the origin and growth of each of these Colleges, founded on abundant data supplied by the authorities of the various institutions. Ample details are given as to the amount and sources of income of each of the five Colleges, the number and kinds of professorships, the income of each Chair, the number of students in each class during the last two years—in short, all information needed to form an opinion as to the kind and comprehensiveness of education which the Colleges aim to give, the means at their command to carry out their ideal aims, and the extent to which they have been successful.

The expenditure of University College, London, on capital account, for all purposes, up to the year 1870, amounted to 202,287*l.*, the whole having been defrayed out of the original share capital of the College, and out of the sums that have been either given or bequeathed to it for general purposes from time to time. In addition to the capital sum thus expended there are endowments arising out of various bequests which produced, in 1870, an annual income of 2,978*l.* Of this income, 2,276*l.* is appropriated to special purposes; no assistance has ever been received from any Government grant.

The School established in connection with the College is of unquestionable advantage to it, as a large and increasing proportion of well-prepared pupils pass from the former to the latter; and during the last few years the College has been slightly a gainer, in a pecuniary point of view, by the maintenance of the School. The scientific Chairs of the College are eleven in number. Of these eleven professorships, one only is endowed, Mr. T J. Phillips Jodrell having lately presented to the College the sum of 7,500*l.* for a permanent endowment of the Chair of Physiology. With the exception of this recent benefaction, the College can hardly be said to possess any endowment whatever the revenue of which is properly applicable to the support of its Scientific Faculty. The Professor of Geology, however, receives 31*l.* per annum from the Goldsmid Fund.

The courses of study, as indicated in the programmes of the professorial lectures, appear to be carefully arranged with a view to the requirements both of elementary and of advanced students. Great importance is attached to the laboratory instruction in Physics, Chemistry, and Physiology. The College has but few scholarships or exhibitions, and of these, none are appropriated exclusively to scientific subjects.

The Report of the Council states that during the session 1873-74 the number of pupils was 1,542; of these, 893 were students in the College, and 649 pupils in the School. Of the students, 322 belonged to the Faculty of Medicine. In the Faculties of Arts and Laws and of Science there were 571. The fees received, exclusive of those for clinical instruction, amounted to 24,266*l.* 10*s.* 6*d.* The total payments out of these fees to the professors, teachers, and masters, amounted to 16,904*l.* 8*s.* 6*d.*, leaving 7,362*l.* 2*s.* for the College share of fees.

The evidence which has been laid before the Commission clearly shows that the usefulness of the College is greatly restricted by the insufficiency of funds. The difficulty is felt in two respects: first, in providing adequate payment for the professors and their assistants; and secondly, in providing laboratory accommodation upon a sufficient scale, together with the proper appliances for instruction and research. The Report gives a schedule of payments to the various scientific professors, followed by a schedule of the lectures given by each; and looked at merely from this point of view alone, the disproportion between the payment and the work done is very striking.

In the opinion of the secretary of the College, "the large deductions from the fees which the College is obliged to make in order to provide for the current expenses of the institution, have a twofold injurious effect. They materially diminish the remuneration of the professors, and so far tend to deprive the College of the services of able men, and by rendering it necessary to charge fees higher than might otherwise be requisite, they must have the indirect effect of keeping down the number of our students. The result is that our professors as a rule are very inadequately paid." The natural consequence of the inadequacy of the professorial stipends is, that in many cases the College has found it impossible to retain the services of some of its most distinguished professors. Some striking instances of very recent occurrence, which show the disadvantage at which the College is placed in this respect, are mentioned in the evidence.

The resources of the College have, moreover, been quite inadequate to provide suitable and sufficient laboratories, apparatus, and assistance for the practical departments of experimental science. The Council have done what they could with the means at their disposal, but these are so inadequate as seriously to cripple the efficiency of the scientific instruction given by the College. Proposals for the extension of the College buildings appear at various times to have come under the consideration of the Council, but no definite action has been taken with regard to them. One of the most important uses to which the additions would be put, were they made would be laboratories for practical study and original research in connection with the various Science Chairs.

The history and constitution of King's College is in some respects similar to that of University College; by its original charter, however, dated 1828, it is intimately associated with the Church of England. It started at first and has all along had to struggle with even greater difficulties than University College. For new buildings and other purposes it has had to incur debt from time to time, more especially to meet the increased demands of physical science, for which more accommodation is urgently needed.

The expenditure of the capital funds of the College from its foundation up to the present time amounts to 180,421*l.* 5*s.* 9*d.*

The schedule of payments shows that, as in the case of University College, the teaching staff is very inadequately paid.

The evening classes at King's College have been eminently successful, and provide a fairly complete course of scientific instruction for persons who are unable to attend the day classes. They were attended in 1873 by as many as 550 students, the majority of whom attended more than one class; about 300 out of the 550 attending Science Classes. The financial relations of the School, which is in a flourishing condition, to the College are substantially the same as at University College.

The same complaint is made in the case of King's as in the case of University College; the chief impediment to its further success is "that it is so extremely poor." The various scientific departments of the College do not pay, and were it not for the theological and literary departments, the College, we fear, would have to shut its doors. The professors ought to get three-fourths of the fees, but often a percentage for college expenses has to be deducted from the small sums thus yielded.

We quote in full the recommendations of the Commission with reference to the two Metropolitan Colleges, recommendations which, if carried out, would undoubtedly increase the efficiency of these Colleges, and from which the country would reap a rich return.

"After carefully reviewing the evidence laid before us with regard to University and King's Colleges, and especially taking into account the great public services which have been rendered by these two institutions to scientific education in the metropolis, we are of opinion that, subject to the reservations which we shall make hereafter, they have established a claim to the aid of Government which ought to be admitted. We think that such Government aid should be afforded, both in the form of a capital sum to enable the Colleges to extend their buildings where requisite, and to provide the additional appliances for teaching which the advance of scientific education has now rendered absolutely necessary; and also in the form of an annual grant in aid of the ordinary working expenses of the Colleges.

"With regard to the grant of a capital sum, we are of opinion that it should be appropriated to definite objects such as those above referred to; and we further think that the amount of such grants should be dependent upon the amounts raised by subscription.

"With regard to the annual grants in aid of the income of the Colleges, we think that they also should be appropriated to definite purposes, such, for instance, as the augmentation of the stipends of certain professorships, the payment of demonstrators and assistants, or payments in aid of the laboratory and establishment expenses. An account of the yearly expenditure of each institution receiving such assistance should be reported to Government. As the suspension or withdrawal of the annual grant would always remain in the power of Parliament, we do not think that it would be necessary or desirable to give the Crown a voice in the appointment of the professors, or any control over the management of the Colleges, other than such visitatorial jurisdiction as would be implied by an annual presentation of the accounts.

"As we do not consider that a day school in the metropolis ought to receive pecuniary assistance from an institution which is itself in receipt of such assistance from Government, our recommendation of Government aid to University College is subject to the reservation that its financial arrangements shall be such as, while enabling the College to do full justice to the School, may prevent the School from becoming a charge upon the funds of the College on an average of years. Our recommendation is also subject to the reservation that the finances of the Hospital, and of the purely medical departments, shall be kept distinct from those of the College generally. Our inquiry has not extended to Medical Schools, and it is not within our province to make any recommendation with respect to Government aid to such schools, whether associated with scientific colleges or not. In the case of University College, where such an association exists, we think it expedient that the annual outlay on the purely medical department should be kept distinct, in order to enable the Government to consider separately the question of aid to the scientific department. At the same time, we do not think that there is any reason why the Boys' School and the Hospital should not continue, as at present, under the management and control of the Council of the College.

"The same reservations apply to our recommendations with regard to King's College. Indeed, so far as King's College Hospital and the Medical School connected with it are concerned, the need of such a reservation is more obvious, because it is admitted that these institutions are a heavy burden upon the resources of the College.

"With regard to King's College, we would further suggest that the College should apply for a new Charter, or for an Act of Parliament, with the view of cancelling the proprietary rights of its shareholders, and of abolishing all religious restrictions (so far as any such exist) on the selection of professors of science, and on the privileges extended to students of science. We consider that any grant of public money which may be made to King's College should be conditional on such a reconstitution of the College as should effect these objects. And we suggest that advantage might be taken of the opportunity thus afforded to introduce into the government of the College such other modifications as the experience of the persons concerned in its management may have shown to be desirable."

J. S. K.

(*To be continued.*)

THE INTERNATIONAL PREHISTORIC CONGRESS OF ANTHROPOLOGY AND ARCHÆOLOGY—STOCKHOLM MEETING

THIS Congress held its inaugural meeting on Aug. 7, and by acclamation elected Count Hamilton its president, and the gentlemen already mentioned in NATURE (vol. x. p. 307) its acting office-bearers.

There was no further business that day; but the 300 foreign members present (the whole Congress amounts to over 1,400) were hospitably entertained in the evening by the town of Stockholm at Hasselbacken, which is to Stockholm what Richmond is to London. There were music, supper, and fireworks; and during the evening, in reply to a well-worded toast of welcome from the Mayor, several good speeches were delivered by members of the council representing the different nations present.

On Saturday the real work of the Congress began, and the questions discussed were—What are the most ancient traces of man in Sweden? and Is it possible to indicate the routes, during antiquity, through which the commerce in yellow amber went?

Baron Kurck opened the discussion by stating that he believed that the most ancient traces of man were to be found in the southern parts of Sweden, and that during the Stone Age men had gradually and slowly travelled northwards, which he thought was sufficiently proved by the fact that the rudest constructed stone implements were found in the south, and that they became more and more mixed with polished ones as you proceeded in a northern direction. The question was entered into with liveleness, and, among others, three of our countrymen, Franks, Evans, and Howorth, took an active part and ably sustained the reputation of Anthropology among British *savans*.

At the Monday's sitting, when a point of great interest was discussed, namely, the characteristics of the polished stones in Sweden, and whether it was possible to attribute the antiquities of this age to one people or to the coexistence of several tribes inhabiting the different parts of Sweden, the King honoured the Congress with his presence. It would appear, too, that he was interested in the speeches, as on a subsequent day he not only himself returned, but brought the Queen with him. The discussion on that occasion was fortunately even more interesting than on the previous occasion, for it was on the Bronze Age, and what were the analogies in the manners and the industry of the Swedish people at that time when compared with those of the same period in the other countries of Europe: also on comparing the Bronze Age with those which preceded it. On Tuesday the Congress visited Upsala (the Oxford of Sweden), and were received and entertained by the professors and students in a most novel and interesting manner. They met us at the railway station, the students all with their white caps on, and carrying the twelve white silk banners, with the embroidered arms and devices of their respective provinces upon them, done in gold and silk thread in a manner which it would be hard to find female fingers at the present day, even when stimulated by Cupid's dart, capable or willing to execute. The choir of students, which I am told is the best in Europe, sang a song of welcome, and then marched before us to the principal points of interest in the town, several times giving us brilliant examples of their vocal powers, especially in the cathedral. Our visit to Upsala was, however, not one entirely for amusement, but for instruction, and a few miles from the town was one of the largest of the country's tumuli, opened for our inspection. It was nearly 40 ft. high, and composed chiefly of sand, covered over with grass, looking like a little hill, but one at whose height and steep sides you would look twice before attempting to ascend. In this were found human remains and the bones of animals (burned) supposed to have been offered in sacrifice. Fragments of gold and iron were also discovered, and a coin, all of which lead to the belief that this tumulus is not more ancient than the fourth century. Another excursion was made on Thursday to the Isle of Björkö, where there is an ancient cemetery of 2,000 tumuli, each about 4 ft. or 5 ft. high, and from 12 ft. to 18 ft. in diameter. Within a couple of hundred yards from this is the site of the ancient town; nothing remains to tell of its site but the souvenirs which lie hid in its soil, which is called the "Black Earth," and is famous for its potatoes. Several trenches, 3 ft. deep and nearly 4 ft. wide, were run through the site of this ancient town, and several of the members of the Congress were fortunate enough to pick up articles of interest—fragments of very rude pottery, needles of bone, glass beads, fragments of iron, and an immense number of the bones of domestic animals, including those of the horse, ox, sheep, dog, cat, pig, as well as of birds. From the remains found here it appears this town must have existed at least up to the eighth century. Before the visit of the Congress to it were found several iron keys, fish-hooks, and pincers: also a whole necklace of coloured glass beads, chiefly white and red; a great many fragments of hair combs, some very well engraved, with crossing straight lines, circles, and dots. They were all formed of bone.

On the following day was discussed the question of how the age of Iron was characterised in Sweden, and an attempt was made to establish the relations at that period which existed between the Swedes and the more southern nations; but, just as on some of the other occasions, no definite conclusion was arrived at, and this arose from the great tendency members showed for discussing the details instead of keeping to the main subject. The last question considered was, what were the anatomical and ethnical characters of the prehistoric men in Sweden? This afforded a second opportunity to the Congress of hearing an interesting passage of arms between Messrs. Virchow and Quatrefages, very similar in substance to what we had from them in print the year after the Franco-German war. They agreed to differ then, and they agree to differ still. It was interesting, but not to the point. However, all ended amicably, and the seventh session of the International Prehistoric Anthropological and Archæological Congress may be said to have terminated by an evening party given by the King of Sweden to all its members at his country palace of Drottningholm, on Saturday, August 15, 1874. Her Majesty and the Queen Dowager were both present. This evening party will long remain in the memory of the members of the Congress as a pleasant tribute of royalty to the shrine of science, reflecting as it does as much credit on the intellectual acumen of him who gave it as honour on those who received it.

The next meeting of the International Prehistoric Anthropological and Archæological Congress will be held at Pesth in 1876.

GEORGE HARLEY

ARMSTRONG'S "ORGANIC CHEMISTRY"

Introduction to the Study of Organic Chemistry. The Chemistry of Carbon and its Compounds. By Henry E. Armstrong, Ph.D., F.C.S. (London: Longmans and Co., 1874.)

TO write a good introduction to any subject is sufficiently difficult, but if the subject be developing very rapidly and undergoing very marked changes, as is the case with organic chemistry, obviously the difficulty of presenting such a subject to a student in a satisfactory manner is vastly increased. Dr. Armstrong has devoted himself heart and soul to his work: the requisite knowledge he evidently possesses, and he has shown good judgment in selecting from much new matter what to bring forward and what to withhold. Neither in arrangement nor in substance has he made direct use of previous treatises on the subject; he has written his own book on organic chemistry, and it certainly will prove to be a good and useful one.

No treatise of note on this subject had appeared of late years in our language, and this rapidly developing branch of science had outgrown the old form in which it had been cast. The change of name which has been suggested is really indicative of the change the science has undergone: formerly it was Organic Chemistry; now it is the Chemistry of the Carbon Compounds; in fact, formerly it was the properties of a few substances, the direct products from organised structures, which was studied, whereas now a very large portion of a treatise on organic chemistry is taken up with the exposition of the theoretical constitution of artificially prepared bodies. In few branches of science has theory been more useful and productive of more good than in this branch of chemistry; and certainly inorganic chemistry, although dealing with simpler bodies, owes much to lessons derived from the organic branch of the subject.

Dr. Armstrong has grouped his subjects in a simple, and, if in somewhat a summary, still in a philosophic way. He casts off and entirely ignores all bodies which at present refuse to fall into some established group. Thus, such bodies as the natural organic alkaloids, indigo, albumen, &c., find at present no place in his book; while we do not regret the exclusion of bodies of doubtful composition, unknown constitution, and but little special interest, still, to ignore the whole of the well-defined class of natural alkaloids was hardly necessary as a matter of principle, and certainly will prove inconvenient to the student.

Since this special property of carbon, this power which it has of combining with itself, appears capable of yielding an almost infinite number of compounds, the classification of this host of bodies becomes a matter of the first importance. So few were the number of organic bodies known only some forty years ago, that they could be classed according to their origin as vegetable or animal substances; afterwards there sprung up a multitude of bodies formed directly or indirectly from these, and we have the first indication of those series of bodies which are now so characteristic of organic chemistry. More or less of the old principle of grouping has lingered in the science until now, but in this book it gives way entirely to grouping dependent solely on constitution; some of the many series of organic bodies are now tolerably complete, and the discovery of new bodies, instead of as formerly tending to complicate the science, now tends to simplify it. In this arrangement of the compounds in series, Dr. Armstrong introduces a simplification which is important; he does away with the aromatic group of compounds as a distinct group, and merges them in the larger general groups. This aromatic group of compounds, as they have been designated, have undoubtedly very marked and specific properties, but Dr. Armstrong shall state for himself his reasons for giving up the exclusion of them from the general series to which they may be considered as belonging, and we think most chemists will be inclined to agree with him:—

"The division of carbon compounds into two great groups of fatty and aromatic substances, which has found favour of late years, has not been adopted. It appears to have arisen from the comparison of single substances, and cannot be sustained, I believe, if whole series are contrasted. It is now placed beyond doubt that in each homologous series of carbon compounds the properties (physical and chemical) of the successive terms undergo from first to last a progressive modification, and there is every reason to believe that in like manner the successive terms in each isologous series undergo a progressive modification. At present we are not acquainted with a single complete homologous or isologous series, so that it is difficult to draw conclusions; but to judge from the evidence at our disposal it appears highly probable that the modification in properties from term to term of each homologous and isologous series is of so gradual a character that continuity may be said to exist throughout. If so, it is as little possible to divide carbon compounds into two great groups as it is to draw a line which shall sharply divide so-called inorganic and organic compounds; that such a division appears possible at present is simply the consequence of the number of links which are still missing in the chain of facts."

While speaking of certain innovations which Dr. Armstrong has introduced into his book, the substitution of the term "unit weight" for combining or atomic weight should be noted: the term certainly has the advantage of being free from all theoretical significance; but if the term *atom* is objected to, the term *combining weight*, already in common use, would, we should have thought, so nearly have expressed Dr. Armstrong's meaning as to save the necessity of introducing a new term. The general arrangement of the book is clear and simple. The first chapter deals with the methods of organic analysis; and should any student be so unfortunate as not to have the opportunity of learning from experiment how organic bodies are analysed, certainly if he reads this chapter he will be well able to picture to himself the kind of way in which the determinations are made. The explanation of the use and meaning of formulæ naturally follow the determination of the data on which they rest. The following caution to students is not uncalled for, and cannot be too strongly impressed upon them. The author says, speaking of rational, constitutional, and structura formulæ: "The use of these terms seems to imply, however, that such formulæ express the constitution or structure of the bodies to which they refer; but we must guard ourselves most carefully against this impression, since, hypothesis aside, we possess no real knowledge as to the internal constitution of chemical compounds, or of the mode of arrangement of the atoms of which bodies are presumed to be made up; and although rational formulæ may represent the approximate constitution of chemical compounds, yet in the present state of our knowledge it is advisable to regard them simply as condensed symbolic expressions of the chemical nature and mode of formation of the compounds represented; they enable us, so to speak, to decipher at a glance the chemical history of compounds."

The second chapter is devoted to the classification of organic compounds, and Dr. Armstrong arranges them all under the following nine heads:—Hydrocarbons, Alcohols, Ethers, Aldehydes, Ketones, Acids, Anhydrides, Amines, and Organio-Metallic Bodies. To each class he devotes a few lines of explanation; in fact, the whole chapter is a general outline of what is to follow, and is very useful as giving a general and comprehensive view of the whole subject. The kind of action exerted by the most important reagents on organic bodies is next described, and will be useful to the student who already has some knowledge of the bodies acted on. After thus disposing of these introductory matters, the systematic study of the different classes of bodies above named is commenced and carried through, chapter by chapter, nearly in the above order, the study of Carbon itself forming the starting-point.

The book will certainly prove of great use in this country and do good service in extending a knowledge of organic chemistry. Students in general will hardly look upon it as an interesting text-book; long lists of rare substances, whose only real interest at present is in their constitution, cannot be made very attractive. The descriptions, however, of important methods of preparation and of purification of different bodies are very well given, and there is a reality and freshness about them which is not generally met with in systematic works on organic chemistry. Dr. Armstrong has evidently not been content to obtain all his information second hand.

The book will probably become the standard text-book on organic chemistry in this country, and in future editions probably will develop into a larger work; at present even it contains much detail, and is suited rather for the advanced student than for the mere beginner.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. No notice is taken of anonymous communications.*]

Mr. Herbert Spencer and Physical Axioms

In my letter, published in NATURE, vol. x. p. 104, I asked the following question—Does Mr. Spencer regard the second law of motion as an "unconsciously-formed preconception," or as a "corollary of a preconception," or as a "consciously-formed hypothesis"?

This led to a correspondence with Mr. Spencer, which he has thought well to publish, with comments, as part of a pamphlet containing appendices to his former pamphlet entitled "Mr. Herbert Spencer and the British Quarterly Reviewer." Consequently, I should be glad if you would allow me space for a few final words to state what now appears to be the result of the controversy.

By the fuller explanation with which Mr. Spencer has favoured me, it has now been made clear that, on his theory of the evolution of physical axioms, the second law of motion is not itself a "preconception," but a "corollary of a preconception," that is, a truth implied in, but only evolved by conscious mental processes from, the preconception; though he afterwards somewhat qualifies this statement by admitting conscious *observation* to have its share in the result, when he says, "*Observation aids* in disentangling the truth that this relation between force and motion is more distinct where the actions are simplest—so leading to the intuition that the proportionality is absolute where the simplicity is absolute." I state this, in fairness to Mr. Spencer, because he lays stress on the distinction, and rightly so from the point of view of psychological theory; though as regards my argument that the second law of motion is not to be regarded as in any sense an *à priori* cognition, it is a side issue of no importance.

But with respect to the main issue, I have at length obtained a definite reply in a passage which I proceed to quote from Mr. Spencer's comments on my last letter to him. I had said—"Various hypotheses as to the relation between force and change of motion may be made, all consistent with the general preconception of the proportionality of cause and effect, and between which the mind alone is unable to decide, until it calls to its aid conscious observation or experiment." To which Mr. Spencer rejoins—(the italics are mine)—"This is perfectly true. I have said nothing to the contrary. My argument implies nothing to the contrary. *I am not concerned with the question how impressed force is to be measured, or how alteration of motion is to be measured.* The second law of motion is a *purely abstract statement, and I hold it to be à priori only in its abstract form.* It asserts that the alteration of motion (a right mode of measurement being assumed) is proportional to the impressed force (a right mode of measurement being assumed). I do not affirm that we know, *à priori*, in what terms of space and time and mass change of motion is to be expressed. The law, as formulated, leaves this unspecified; and all I hold to be *à priori* is that which is alone stated in the law."

To the mathematician and physicist, comment on this is hardly necessary. I was right when I said, in a former note, that there is little left to argue about. The osteologist may doubtless for his own purposes speak of the skeleton of a horse as a horse, though the dry bones would be a sorry substitute for the living animal to a man who wanted it to do his work. And so, too, Mr. Spencer, as a psychologist, might (if it did not lead to that disastrous confusion which we have complained that his use or misuse of the terms of physical science does lead to) speak of the second law of motion "in its abstract form" as the second law of motion; but assuredly Newton, who had carefully defined quantity of motion and of motive force before enunciating his "Axiomata sive Leges Motûs," did not regard it as a "purely abstract statement;" and every mathematician and physicist, who has to any extent followed in Newton's steps, knows that all that gives life and force—that is, power to generate new results and to co-ordinate and explain the external phenomena with which physics is concerned—to this or any other physical axiom is not its *à priori* basis or abstract form, but that element in it which has been derived from conscious observation or experiment.

The upshot of the whole controversy, then, is that the physical axioms of Mr. Spencer are not the living truths which form the basis of the physical sciences, but the bare abstract forms in which those truths may conveniently—possibly Mr. Spencer would say *must*—be expressed. I trust that the value of this result, to the readers of Mr. Spencer's first principles, may be some atonement for the space and time which the controversy has occupied.

ROBERT B. HAYWARD

Harrow

Darwin on "The Origination of Life"

We are constantly meeting with an objection to Mr. Darwin's writings, urged alike by friends and foes, on the score of his not having published his views concerning the origin of life. As this objection refers to a matter of literary taste rather than to anything of substantial importance, in ordinary cases it is best met by silence; but when a President of the British Association gives it a prominent position in his inaugural address, it is time that a dissentient view should be raised.

Towards the close of his discourse, Dr. Tyndall observes:—"The *origination* of life is a point lightly touched upon, if at all, by Mr. Darwin and Mr. Spencer. Diminishing gradually the number of progenitors, Mr. Darwin comes at length to one 'primordial form;' but he does not say, as far as I remember, how he supposes this form to have been introduced. He quotes with satisfaction the words of a celebrated author and divine who had 'gradually learnt to see that it is just as noble a conception of the Deity to believe He created a few original forms capable of self-development into other and needful forms, as to believe that He required a fresh act of creation to supply the voids caused by the action of His laws.' What Mr Darwin thinks of this view of the introduction of life I do not know. Whether he does or does not introduce his primordial form by a creative act, I do not know. But the question will inevitably be asked, 'How came the form there?' . . We need clearness and thoroughness here," &c. Now, I submit that although this is a question which must "inevitably be asked," it is nevertheless a question with which Mr. Darwin has nothing whatever to do. The problem concerning the origin of life is as distinct from that concerning the origin of species, as any two problems can well be; and it does not devolve upon a writer to speculate upon the one, merely because he has solved the other. Those who have taken the greatest interest in Mr. Darwin's illustrious career cannot have failed to appreciate the admirable forbearance he has always displayed in not allowing himself to digress into collateral topics, however great the temptation to digress may be. All his vast and numerous conquests of thought have been achieved by a rigid adherence to the philosophy of fact; there is a grand consistency in the maintaining of a method, according to which pure speculation is nowhere permitted to assert itself, excepting in so far as it is absolutely necessary. Surely it would be a deplorable thing were "the epoch-making book" allowed to present a gratuitous deviation from this method, merely in order to plunge into a sea of *à priori* conceptions where inductive verification is as yet impossible. The passage quoted by Prof. Tyndall is adduced by Mr. Darwin only in order to show that *so far as the doctrine of the transmutation of species is concerned*, the evolution theory supplies us with "just as noble a conception of the Deity" as does the theory of special creation. Regarding the more ultimate question, everyone must say with Dr. Tyndall, "What Mr. Darwin thinks of the introduction of life I do not know;" and this, I take it, is just the condition in which the author of the "Origin of Species" should allow his opinions to take their place in history. In short, those who censure Mr. Darwin for his praiseworthy reticence regarding "the far higher problem of the essence or origin of life, upon which science as yet throws no light," * would do well to consider the beautiful example of scientific caution that is afforded by the manner in which this very subject is treated of in the concluding pages of the last edition of the "Origin;" and I am sure that I am only expressing the opinion of the majority of Mr. Darwin's admirers when I say, that whatever our ontological views may happen to be, we all unite in sincerely hoping that, in subsequent editions, he will not spoil the splendour of his finished work by indulging in speculations as foreign to his subject as they must be unprofitable in themselves.

Aug. 21 A DISCIPLE OF DARWIN

* "Origin of Species," p. 421, 1874.

Meteors

ON referring to my record of meteors for the 8th inst., I find two meteors nearly at the times mentioned by Prof. Tait (vol. x. p. 305), viz., 10.33 and 10.53. That at 10.33 was, from its position as seen here, unquestionably *not* identical with the one he saw. That at 10.53 may possibly be the same, if by Monoceros Prof. Tait means the constellation commonly marked at Equuleus. If such is the case, a calculation, rough as the data necessitates, would give for the meteor's height at the beginning 144 miles; at the end, 87 miles.

I have of course had to assume a path for the northern station, but as the radiant point was indicated, and one point of the meteor's course, I had not much choice in the matter.

Birmingham, Aug. 24 THOS. H. WALLER

ANOTHER NEW COMET

THE following communication, dated Mr. Bishop's Observatory, Twickenham, Aug. 20, has been sent to the *Times* by Mr. J. R. Hind, F.R.S.:—

"We have received to-day from M. Stephan, director of the Observatory at Marseilles, telegraphic notice of the discovery of a comet this morning by M. Coggia, in the constellation Taurus, the position of which is thus given:—

"August 19, at 14h. 33min. mean time at Marseilles.—Right ascension, 59° 29′; Polar distance, 62° 55′ Motion towards the south-east. The comet is faint.

"The comet discovered at the same observatory by M. Borrelly, on the 25th of July, I observed here last night as follows:—

"August 19, at 9h. 27min. 38sec. mean time at Twickenham. Right ascension, 13h. 32min. 7·58sec.; Polar distance, 17° 21′ 42·3″

"It does not appear, as yet, to have materially decreased in brightness."

THE BRITISH ASSOCIATION AT BELFAST

BELFAST, *Tuesday Night*.

BELFAST is quite the centre of Irish industry, and one of the most progressive towns in the kingdom. People are living who remember it with less than 20,000 inhabitants; now it has near 200,000. As a proof of industry and thrift, it offers a good example to the rest of Ireland. The Association has not met under very favourable circumstances, for unfortunately at this moment no less than 20,000 men in the town are on strike, and somewhat less than 15,000*l*. a week is withdrawn from circulation. A smaller town with a less elastic population would be paralysed, and the influence of the strike is sufficiently felt as it is. The population of the town is very mixed; it is not true Irish. Belfast is less Irish either than Dublin, Cork, Galway, Derry, or Limerick. There is a large leaven of Scotch and Scoto-Irish, who have indeed the merit of a thrifty nature, but who lack many of the good qualities of the Irish; among others, their hospitality. The thrift of these people has caused the hotel and lodging arrangements to be carried out in an abominable manner. We have been shamefully fleeced. One hotel charges a sovereign a night for a bedroom, others half as much; in any case, members of the Association are charged at least double the ordinary prices. In final despair we were driven to inquire at a small coffee-shop whether they had a room; the people replied that they had; but that if we were a member of the Association we must pay ten shillings a night, the ordinary price in that house being about two shillings. When people travel from a distance, and sacrifice time, money, and rest, to do the work of the Association, and not as pleasure seekers, it is rather hard to be swindled because you happen to be a member of the Association.

The Sections have been well filled, and have had plenty of pabulum in the form of papers and verbal communications. Section A has been divided into two Departments, and it is probable that one or two of the Sections will have to sit on Wednesday. The addresses were quite up to the average. Among the more interesting papers were those of Mr. Huggins, On the Spectrum of Coggia's Comet; Prof. Wiedemann, On the Magnetisation of Chemical Compounds; Dr. Carpenter, On the *Challenger* Deep-sea Dredgings; and Mr. E. J. Harland, On a Screw-lowering Apparatus for Ships. The expected fight about the *Eozoön Canadense* did not come off. The specimen and apparatus room is well filled. Among the more interesting objects we observe Prof. Barrett's apparatus for showing the elongation of iron, cobalt, and nickel by magnetisation, Mr. Braham's heliostat and ruled glass used in experiments on light, and Mr. Roberts' illustrations of columnar structure, artificially produced. The Thursday *soirée*, on the other hand, was singularly devoid of exhibitions of any kind, and the Ulster Hall was extremely crowded, both causes tending to make the evening drag rather heavily. There were several excursions on Saturday, and there are many prepared for Thursday, the principal being to the Giants' Causeway. The Mayor, who has throughout been very active in forwarding the interests of the Association, has issued invitations for a trip round the coast on Thursday, for which purpose he has engaged one of the fine Fleetwood mail steamers.

The Association meets next year at Bristol, Sir John Hawkshaw C.E., F.R.S., being President-elect; Glasgow is to be the place of meeting in 1876, an influential deputation having attended the Association to urge upon it the claims of that city to the honour of its presence. Plymouth will probably be the rendezvous for 1877.

The following is the financial statement of the Association for the past year:—

RECEIPTS.

	£	s.	d.
To balance brought from last account	£924	15	10
Life Compositions at Bradford Meeting, and since	358	0	0
Annual Subscriptions do. do.	646	0	0
Associates' Tickets do. do.	796	0	0
Ladies' Tickets do. do.	601	0	0
Dividends on Stock	237	10	0
Sale of Publications	21	18	1
Balance of Grant made at Brighton to the Sewage Committee	26	8	7
	£3,611	12	6

PAYMENTS.

	£	s.	d.	£	s.	d.
Expenses of Bradford Meeting, also sundry Printing, Binding, Advertising, and Incidental Expenses ...				£373	8	4
Printing, Engraving, &c., Report of 42nd Meeting (vol. 41), Brighton				696	13	10
Ditto on Account of Report of 43rd Meeting (vol. 42), Bradford				58	13	5
Salaries (one year)				462	6	0
Rent and Office Expenses (Albemarle Street) ...				104	5	0
Grants made at Bradford Meeting, viz. :—						
Zoological Record				100	0	0
Chemistry Record				100	0	0
Printing Mathematical Tables				100	0	0
For Committee on—						
Elliptic Functions				100	0	0
Lightning Conductors				10	0	0
Thermal Conductivity of Rocks				10	0	0
Anthropological Instructions, &c...				50	0	0
Kent's Cavern Explorations				150	0	0
Luminous Meteors				30	0	0
Intestinal Secretions				15	0	0
British Rainfall				100	0	0
Essential Oils				10	0	0
Sub-Wealden Exploration				25	0	0
Settle Cave Exploration				50	0	0
Mauritius Meteorological Researches ...				100	0	0
Magnetisation of Iron				20	0	0
Marine Organisms				30	0	0
Fossils, North-west of Scotland				2	10	0
Physiological Action of Light				20	0	0
Trades' Unions				25	0	0
Mountain Limestone Corals				25	0	0
Erratic Blocks				10	0	0
Dredging, Durham and Yorkshire ...				28	5	0
High Temperature of Bodies				30	0	0
Siemens's Pyrometer				3	6	0
Labyrinthodonts of Coal-Measures				7	15	0
Widow of W. J. Askham				50	0	0
Aug. 19, Balance at Bank ...	£698	10	5			
Ditto in hands of General Treasurer	15	19	6			
				714	9	11
				£3,611	12	6

SECTION B

CHEMICAL SCIENCE.

Opening Address by the President, Prof. A. Crum Brown, M.D., F.R.S.E., F.C.S.

One hundred years have elapsed since the discovery of oxygen by Priestley. Perhaps we should say rediscovery, for there is no doubt that about one hundred years earlier Mayow prepared from nitre nearly pure oxygen, and observed and recorded some of its most marked properties. Mayow's discovery, however, led to nothing, while Priestley's was the most important step in that reconstruction of speculative chemistry which was commenced by Black and carried on with surprising energy and thoroughness by Lavoisier and his associates. I shall not detain you by enumerating the ways in which this discovery has affected chemistry both practical and speculative. The pre-eminent position to which oxygen was at once elevated, and which it so long retained, makes this altogether unnecessary. I wish, however, to point out one character of the phlogistic controversy which sharply distinguishes it from many others. The truth represented by the theory of Phlogiston was not recognised with sufficient distinctness by the supporters of that theory to give them any chance of success in opposition to a band of devoted adherents of a view which was clearly understood by all. The phlogistists were completed defeated, and the theory ceased to exist. It has been left for chemical antiquaries to pick out, with difficulty and uncertainty, a meaning from the ruins.

I have mentioned this character because I wish to draw your attention to another more recent controversy, the result of which was very different.

The questions as to chemical constitution raised about forty years ago by Dumas and the new French school, in opposition to Berzelius, may now be said to be practically settled. The great majority of chemists are agreed as to what is to be understood by chemical constitution, and also as to the nature and amount of evidence required in order to determine the constitution of a substance. How has this agreement been produced? Some historical writers seem to wish us to believe that it is the result of the triumph of the ideas of Dumas, Gerhardt, and Laurent, and the defeat of the dualistic radical theory of Berzelius; that the arguments of Berzelius and his followers were only useful as giving occasion for a more full and convincing proof of the unitary substitution theory than would otherwise have been called for; that, in fact, the adherents of dualism played the part (not unfrequently supposed to be that of the Conservative party in politics) of checking and criticising the successive developments of truth, and thus allowing them time to ripen.

In opposition to the view thus broadly stated, I would place another, and for the sake of contrast shall state it also in perhaps too broad a form :—That the two theories, the dualistic radical theory and the unitary substitution theory, were both true and both imperfect, that they underwent gradual development, scarcely influenced by each other, until they have come to be almost identical in reference to points where they at one time seemed most opposed.

I have said that the development of the one theory was scarcely influenced by that of the other. Of course the *facts* discovered by both parties were common property, and the development of both theories depended upon the discovery of these facts; but the explanations of facts and the reasoning from them given by each party seemed to the other scarcely worthy of serious consideration, and were treated as matter of ridicule. And the habit of mind created by this mode of viewing the opposed theory rendered it difficult for those who were engaged in the controversy on either side to see how nearly the two theories have now come to coincidence. Their language still remains different; but as the facts are the same for both, it is not difficult for a neutral critic to translate from the one to the other; and if we do so we shall see that there is much real agreement between the two modes of representing chemical ideas, historically derived, the one from Berzelius, the other from Dumas, Laurent, and Gerhardt.

In both, chemical constitution is regarded as *the order in which the constituents are united in the compound*; and the same fundamental notion is indicated in the one by reference to proximate constituents, in the other by the concatenation of atoms. To show that this is so, and that the fundamental notion can be arrived at from the dualistic as well as from the unitary starting point, I shall cite an illustrative case. Every student of chemical history will remember the view of the constitution of trichloracetic acid propounded by Berzelius, and afterwards supplemented by a similar view of the constitution of acetic acid and an explanation of the likeness of some of the properties of these two substances. This has sometimes been spoken of as a subterfuge of a not very creditable kind, by means of which Berzelius apparently saved his consistency while really yielding to the arguments of his opponents. But if, instead of looking at it in the light of the substitution controversy, we consider it in itself as a contribution to speculative chemistry, we at once recognise in it a statement, in Berzelian language, of the views we now hold as to the constitution of these acids. The view was that acetic acid is a compound of oxalic acid and methyl, trichloracetic acid a compound of oxalic acid and the sesquichloride of carbon. They differ considerably from each other, because the "copulæ" (methyl and sesquichloride of carbon respectively) are different; but their resemblance is strongly marked, because they contain the same active constituent, oxalic acid; and most of the prominent characters of the substances depend upon it, and not upon the copulæ. Let us first free this statement from what we may call archaisms of language. It will then assume something like the following form: The carbon in acetic acid is equally divided between two proximate constituents, one of which is an oxide, the other a hydride of carbon. Trichloracetic acid similarly contains an oxide and a chloride of carbon, between which the carbon is equally divided. The oxide is the same in both acids, and is that oxide which occurs in oxalic acid. The hydride and the chloride have the composition of the substances, the formulæ of which are C_2H_6 and C_2Cl_6 respectively. Oxalic acid undergoes chemical change much more readily than the corresponding hydride or chloride; and therefore the chemical character of acetic and of trichloracetic acids depends much more on the oxidised than on the other constituent, and they thus have a marked resemblance. The oxidised constituent is united to the other in a manner different from that in which oxalic acid is united to bases in the oxalates, inasmuch as, while the basic water of hydrated oxalic acid is displaced when oxalic acid unites with a base, in hydrated acetic and trichloracetic acids there is the same proportion between the basic water and the oxidised carbon as there is in oxalic acid.

Now, has not this a great resemblance to the view entertained by most modern chemists, that acetic acid is a compound of the radical carboxyl (half a molecule of oxalic acid) and the radical methyl (half a molecule of methyl gas), that trichloracetic acid similarly contains the same radical carboxyl and the radical CCl_3, and that the prominent chemical properties of these bodies depend upon their containing carboxyl, and that they therefore resemble each other?

The modern view contains nothing inconsistent with that of Berzelius; but it no doubt contains something more: it contains an explanation of the difference between the manner in which carboxyl is united to methyl in acetic acid, and the manner in which oxalic acid is united to bases in the oxalates. But it will surely be admitted that Berzelius was here far ahead of his opponents—so far ahead, that they altogether failed to see his meaning, and looked upon his argument as a clumsy device.

The treatment by Berzelius of the constitution of the sulpho-acids, furnishes a precisely similar case. These are now regarded as compounds of the radical SO_2OH (which we may call sulphoxyl). This radical is half a molecule of hyposulphuric acid; and Berzelius considered them coupled compounds of hyposulphuric acid, adopting at once the view first brought forward by Kolbe in his classical memoir on the sulphite of perchloride of carbon and the acids derived from it.

I might pursue the history of the carbon- and sulpho-acids further, and trace the development of the theory of their constitution through the discoveries of Kolbe, and his beautiful application to the cases of carbon and sulphur of Frankland's far-sighted speculation on the constitution of the organo-metallic bodies, pointing out the relation of Kolbe's views of the constitution of acids, alcohols, aldehydes, and ketones, to the Berzelian theory on the one hand, and to the opinions of modern chemists on the other; but the greater part of such an historical sketch has been given very recently by Kolbe himself in the *Journal für praktische Chemie*, and I may therefore omit it.

It would be easy to bring forward cases to show that our present views can be directly derived from the substitution theory and the types of Dumas and Gerhardt, through the complications of multiple and mixed types, and the labyrinthine formulæ to which these gave rise, to the wonderfully simple and comprehensive system of Kekulé; but that is unnecessary, as this development has been fully and ably described by more than one thoroughly competent writer.

We have been discussing a case in which Berzelius was right in considering a compound of carbon, oxygen, and chlorine as composed of two parts—an oxide and a chloride of carbon. It is only just that we should only take some notice of cases, at first sight similar, in which modern chemists would be inclined to think that he was wrong. This is the more necessary, as an examination of these cases will enable us to see what was the really valuable contribution made to speculative chemistry by the substitution theory.

Compounds containing three elements were formulated in two different ways by Berzelius:—

1. One of the elements was represented as combined with a radical composed of the other two, as hydrocyanic acid, $H_2 \cdot C_2N_2$; ether, $C_4H_{10} \cdot O$.

2. The ternary compound was represented as composed of two binary compounds, having one element common, as caustic potash, KO, H_2O; chromochloric acid, $2CrO_3, CrCl_6$.

Phosgene gas was at first formulated in the former of these ways as CO, Cl_2; but latterly he was forced, in consistency, to give up all radicals containing oxygen or other strongly electro-negative element,* and to write the formula of phosgene gas CO_2, CCl_4. Similarly, in every case where a positive element or radical is combined with two negative elements or radicals, he represented the compound as composed of two binary compounds, thus—chloride of acetyl, $2C_4H_6O_3, C_4H_6Cl_6$, as a compound of acetic acid and the corresponding terchloride.

This was in perfect consistency with the mode in which ternary compounds containing one negative and two positive elements or radicals were formulated, as caustic potash, KO, H_2O, sulphate of copper, CuO, SO_3, &c.; but it lacks the practical justification which can be given for the formula C_2H_6, C_2O_3 for acetic acid; for phosgene acts readily on water, forming carbonic and hydrochloric acids, an action which does not take place with perchloride of carbon; and it is not easy to see why the latter substance should be more readily attacked by water when combined with carbonic acid than when free. This difference did not escape the attention of Berzelius, and led him to distinguish two modes of chemical union: (1) where the constituents were held together by the electro-chemical force, and wholly or partially neutralised each other, as in the oxygen and sulphur salts; and (2) where a so-called "copula" was attached by an unknown force to a substance without greatly modifying its chemical activity. The distinction seems arbitrary; but it was not, as is usually supposed, a mere artificial bulwark to protect the electro-chemical theory; it has a real and very important meaning, a meaning which the development of the substitution theory enables us to explain.

The phenomena of electrolysis, upon which the Berzelian system is based, bring forward into great prominence *one* of the chemical units, viz. the *equivalent;* and the pre-eminent position of oxygen as the most electro-negative element made it most natural to select the atom of oxygen as the standard of equivalence, so that an equivalent of any element or radical was defined as that quantity of it which is equivalent to one atom of oxygen. Gay-Lussac's law of gaseous volumes, which was adopted by Berzelius, and which, by a curious accident, happens to be true for all elements gaseous at ordinary temperatures, led to the formulæ H_2 and Cl_2 for the *equivalents* of hydrogen and chlorine; but although these formulæ explicitly indicate the divisibility of the equivalents of these elements, this divisibility was not recognised, and integral numbers of equivalents were alone tolerated. Thus hydrochloric acid was written H_2Cl_2, ammonia N_2H_6, &c., and the etymological meaning of the word atom was soon lost. The use of barred letters to indicate two atoms or one equivalent of such elements as hydrogen and chlorine further contributed to hide the important fact of their divisibility.

The first great result of the substitution theory was to change the unit of equivalence, and to take as the standard the atom of hydrogen or of chlorine instead of that of oxygen; and although it would be most unjust to forget the services of Dumas, Gerhardt, Laurent, and Odling in this matter, the credit of removing the bars from H, Cl, and their comrades, and allowing the hitherto chained partners to walk at liberty, undoubtedly belongs mainly to our distinguished colleague and master, Prof. Williamson.

The establishment of the water type, or (to put it in another form) the proof that the atom of oxygen contains two units of oxygen, inseparably united but capable of separate action, led the way to the explanation of all the difficulties which beset the theory of radicals and copulæ. It at once explained how two oxides or two sulphides unite together;* and the idea of "polybasic," or, as we should now say, polyad atoms and radicals, was soon used to explain the existence of polybasic acids, double salts, acichlorides, and many other kinds of ternary compounds.

But a fact does not cease to exist because it is explained. Quicklime and water unite together, although we can now explain how they do so; and a useful purpose may still be served by the enumeration, as in the old dualistic formulæ, of the pairs of united equivalents. Although some of these equivalents belong to the same atoms, it is nevertheless true that they are united in pairs. Caustic potash might thus be formulated, $KO\frac{1}{2}, HO\frac{1}{2}$ or $\frac{1}{2}(K_2O, H_2O)$; phosgene gas, $\frac{1}{2}(CO_2, CCl_4)$; and chlorochromic acid, $\frac{1}{3}(2CrO_3, CrCl_6)$. These formulæ are not so well suited for general use as those now current; but the consideration of them as accurate representations of facts may enable us to see that the copulæ of Berzelius had a real and valuable meaning. Take, for instance, the formula of acetic acid, $H_3C—CO—OH$, or $\frac{1}{4}CH_4, \frac{1}{4}CO_2, \frac{1}{2}H_2O, \frac{1}{4}C_2$; it is this last term which indicates the coupled character of the compound. If we look upon acetic acid as a compound of carbon, it is a coupled compound because

* In 1843 Berzelius was inclined to regard C_2O_3, to which he gave the name "oxatyl," as the radical of oxalic acid and oxamide.

* It does not explain the existence of double chlorides, bromides, &c. These compounds, apparently so similar to the double oxides and sulphides, are still unexplained.

all the equivalents of carbon in it do not belong to the same atom, and the two atoms of carbon are directly united together, and replacement of the equivalents united to one of these atoms does not very greatly affect the function or chemical character of the equivalents united to the other.

I have perhaps spent too much of your time upon these historical questions. Let us now shortly consider what is the present state of our knowledge as to chemical constitution. This I have already defined as the order in which the constituents are united in the compound. We may indeed use metaphorical language, and speak of the relative position of atoms, perhaps deluding ourselves into the notion that such language is more than metaphorical; but the phenomena of combination and decomposition, although we cannot doubt that they depend solely upon the relative position and dynamical relations of the atoms, are not alone sufficient to prove even that atoms exist. Our knowledge of the intimate structure of matter comes from another source—from the study of the properties rather than of the changes of substances, and of the transformations of energy which accompany the transformations of matter.

This is strictly a branch of chemistry: the aim of chemistry is to connect the properties of substances and the changes they undergo with their composition, taking this word in its widest sense; and we must not allow our friends in Section A to cut our science in two and appropriate the half of it. We all frankly admit that chemistry is a branch of physics; but it is so as a whole—no section of it is more purely physical than all the rest. To accept a narrower definition of chemistry is to reduce ourselves to the position which the collector occupies among naturalists; it is to admit that it is our business to provide part of the materials out of which a science in which we have no share may be constructed by others. But we need not fear that this so-called physical side of chemistry will ever be divorced from the study of chemical change. The names of Faraday and Graham among those who have left us, of Andrews among those who are still at work, are sufficient proof of this; and a study of their researches will conclusively show that great results can be looked for in this direction only from a physicist who is also a chemist.

There are three special directions in which such investigations have already influenced chemical theory:—1. *Electrolysis*, which has confirmed the equivalent as a chemical unit, has proved that equivalents unite in pairs, thus forming the basis of electro-chemical theory, and has shown us how to estimate the amount of energy involved in the union of a given pair of equivalents. 2. *Vapour-density*, from which Avogadro inferred the law of molecular volumes (since proved by Clerk-Maxwell), which has given us the molecule as a chemical unit, and formed the basis of the unitary theory. 3. *Specific heat*, from which Dulong and Petit inferred their empirical law, which gives us the most satisfactory physical definition of the atom as a chemical unit.

We naturally turn to the future, and try to guess whence the next great revolution will come. For although periods of quiet have their use, as affording time for filling up the blank schedules furnished by the last speculative change, such periods have seldom been long, and each has been shorter than its predecessor.

But it is impossible to make a certain forecast: looking back, we see a logical sequence in the history of chemical speculation; and no doubt the next step will appear, after it has been taken, to follow as naturally from the present position. One thing we can distinctly see—we are struggling towards a theory of chemistry. Such a theory we do not possess. What we are sometimes pleased to dignify with that name is a collection of generalisations of various degrees of imperfection. We cannot attain to a real theory of chemistry until we are able to connect the science by some hypothesis with the general theory of dynamics. No attempt of this kind has hitherto been made; and it is difficult to see how any such attempt can be made until we know something in reference to the absolute size, mass, and shape of molecules and atoms, the position of the atoms in the molecule, and the nature of the forces acting upon them. Whence can we look for such knowledge?

The phenomena of gaseous diffusion, of gaseous friction, and of the propagation of heat through gases, have already given us an approximation to the size and mass of the molecules of gases. It is not unreasonable to suppose that a comparative study of the specific heat of gases and vapours may lead to some approximate knowledge as to the shape of their molecules; and a comparison of such approximate results with the chemical constitution of the substances may lead to an hypothesis which will lay the foundation of a real theory of chemistry.

Chemistry will then become a branch of applied mathematics; but it will not cease to be an experimental science. Mathematics may enable us retrospectively to justify results obtained by experiment, may point out useful lines of research, and even sometimes predict entirely novel discoveries, but will not revolutionise our laboratories. Mathematical will not replace Chemical analysis.

We do not know when the change will take place, or whether it will be gradual or sudden; but no one who believes in the progress of human knowledge and in the consistency of Nature can doubt that ultimately the theory of Chemistry and of all other physical sciences will be absorbed into the one theory of Dynamics.

SECTION E

GEOGRAPHY

OPENING ADDRESS BY THE PRESIDENT, MAJOR WILSON, R.E.

THE President of the Royal Geographical Society has so recently delivered his anniversary address, that if I were to attempt to trace the progress of geographical discovery during the period that has elapsed since the meeting of the British Association at Bradford in September last, I could scarcely avoid repeating much that has already been said in far abler terms than I have it within my power to command. Still there are, at the present moment, certain subjects of such very general interest and of so much importance that they cannot well be passed over in any address to the Geographical Section of the British Association.

It has, I believe, been usual in the addresses to this Section to select some special subject for remark, and I will therefore, if you will allow me, before alluding to the geographical achievements of the year, draw your attention to the influence which the physical features of the earth's crust have on the course of military operations; to the consequent importance of the study of physical geography to all those who have to plan or take part in a campaign; and to the contributions to geographical science that are due, directly or indirectly, to war, and the necessity of preparing for war. To show how varied are the conditions under which war has to be carried on, and how much its successful issue may depend on a previous careful study of the physical character of the country in which it is waged, it is only necessary to remind you of the recent operations on the Gold Coast, brought to a successful issue in an unhealthy climate, and in the heart of a dense tropical forest, where an impenetrable undergrowth, pestilential swamps, and deep rivers obstructed the march of the troops; of the Abyssinian expedition, landing on the heated shores of the Red Sea, and thence, after climbing to the lofty frozen highlands of Abyssinia, working its way over stupendous ravines to the all but inaccessible rock, crowned by the fortress of Magdala; of the march of the Russian columns across the steppes and deserts of Central Asia to the Khivan oasis, one month wearily plodding through deep snow, the next sinking down in the burning sand, and saved from the most terrible of disasters by the timely discovery of a well; and, lastly, of the great struggle nearer home, the last echoes of which have hardly yet passed away, when the wave of German conquest, rolling over the Vosges and the Moselle, swept over the various provinces of France. The influence of the earth's crust on war may be regarded as twofold: first, that which it exerts on the general conduct of a campaign; and, second, that which it exerts on the disposition and movement of troops on the field of battle. Military geography treats of the one, military topography of the other; and it is well to keep this broad distinction in view, for, as with strategy and tactics, they stand in such close relation to each other that it is not always easy to say where geography ends and topography begins. Of special importance in the first case are great inequalities or obstacles that confine or obstruct the movement of large bodies of troops, and those features that retard or accelerate their march. The climate of the theatre of war must always have an important influence on military operations, and should be the subject of careful study. Our own experience in the Crimea shows how much suffering may be caused by want of forethought in this respect. General Verevkin's remarkable march of more than a thousand miles, from Orenburg to Khiva, with the thermometer ranging from 24° below zero to 100°, without the loss of a man, shows what may be accomplished with due preparation. Nor should the geological structure of a country be over-looked in its influence on the varied forms which the earth's crust assumes, on the presence or otherwise of water, on the supply of metal for repairing roads, and, if we may trust somewhat similar appearances on the Gold Coast, at Hong Kong, and in the Seychelles, on the healthiness or unhealthiness of the climate. It is scarcely necessary to remind you that though mountain ranges and rivers materially affect the operations of war, they are by no means insurmountable obstacles. The Alps have been repeatedly crossed since the days of Hannibal; Wellington crossed the Pyrenees in spite of the opposition of Soult; Diebitsch the Balkan, though defended by the Turks; and Pollock forced his way through the dreaded Khyber; whilst there is hardly a river in the length and breadth of Europe that has not been crossed, even when the passage has been ably disputed. This is hardly the place to discuss the minuter details of military geography and topography: they will be found in the works specially devoted to the subject.

Queen Elizabeth's Minister was right when he said that "Knowledge is power;" and a knowledge of the physical features of a country, combined with a just appreciation of their influence on military operations, is a very great power in war. A commander entering upon a campaign without such knowledge may be likened to a man groping in darkness; with it he may act with a boldness and decision that will often ensure success. It was this class of knowledge, possessed in the highest degree by all great commanders, that enabled Jomini to foretell the collision of the French and Prussian armies at Jena in 1807, and in later years enabled a Prussian officer, when told that MacMahon had marched northwards from Chalons, to point unerringly to Sedan as the place where the decisive battle would be fought. As, then, all military operations must be based on a knowledge of the country in which they are to be carried on, it should never be forgotten that every country contiguous to our own—and the ocean brings us into contact with almost every country in the world—may be a possible theatre of war, and that it is equally the duty and policy of a good Government to obtain all possible information respecting it. Is it with much satisfaction that we can turn to the efforts made by this country to acquire that geographical knowledge which may be of so much importance in time of need? Though we had for years military establishments on the Gold Coast, and though we had more than once been engaged in hostilities with the Ashantees, and might reasonably have expected to be so again, no attempt appears to have been made to obtain information about the country north of the Prah, or even of the so-called protected territories. The result was that when the recent expedition was organised, the Government had to depend chiefly on the works of Bowdich, Dupuis, and Hutton, written some fifty years ago, and on a rough itinerary of the route afterwards followed by the troops, for their information relating to the country and its inhabitants. What advantage has been taken of the presence of the officers who have been in Persia during the last ten years to increase our knowledge of that country—knowledge which would be very useful at present in the unsettled state of the boundary questions on the northern and north-eastern frontiers? How little has been added to our knowledge of Afghanistan since the war in 1842? and what part did India take in Trans-Himalayan exploration before Messrs. Shaw and Hayward led the way to Yarkand and Kashgar? It was with feelings of no slight satisfaction that many of us heard last year that the policy of isolation and seclusion which India appears to have adopted as the last soldier of Pollock's relieving force recrossed the Indus was at last to be broken, and that an expedition well found in every respect was to be sent to Kashgar. It seemed an awakening from the long slumber of the last thirty years, during which we were content to stay at home in inglorious ease, resting under the shadow of the great mountain ranges of Northern India, whilst we sent out mirzas and pundits to gather the rich store of laurels that hung almost within our grasp. Far be it from me to depreciate the valuable services of those gentlemen—services frequently performed at great personal risk and discomfort; but who can compare the results they obtained with those that would have been brought back by English officers, or by travellers, such as Mr. Shaw, Mr. Ney Elias, and others? It has been said that if officers travelled in countries where Government could no longer protect them, they might be killed by the natives, and that then, if the murders were not punished, England would suffer loss of prestige. But is this the case? As a matter of fact, the number of travellers who lose their lives at the hands of the natives of the countries in which they are travelling is quite insignificant when compared with the number of those who return in safety. Let us, then, hope that the Kashgar mission may date the commencement of a new era, during which geographical enterprise may be encouraged, or at any rate not discouraged, amongst the officers of the army, and if few will now deny that a knowledge of Ashantee, of Yemen, of the northern and north-eastern frontiers of Persia, of Merv, Andkin, Maimana, Badakshan, and Wakhan, would have been of importance in the years just passed, it may not be forgotten that a knowledge of these countries may be of still more importance in a not far distant future. May we not take a hint in this respect from our now near neighbours in Central Asia, the Russians? No one who has followed their movements can fail to have been struck by the intense activity of their topographical staff—an activity that can only be compared to that of England at the period when Burnes, Eldred Pottinger, Wood, Abbott, Connolly, and others whose names are ever fresh in our memories, were penetrating into the wildest recesses of Central Asia. In alluding to the contributions of war to geographical science, it is perhaps hardly necessary to mention the very obvious manner in which military operations teach us geography by directing our attention for the time being to the country in which they are being carried on, or to the direct results that have followed many campaigns from the days of Alexander to our own. The Russians are indeed far in advance of us in all that relates to those survey operations and that geographical exploration which should always be carried on simultaneously with the advance of an expeditionary force into an unknown or but partially known country; they have long since realised the importance, almost necessity, of accurate geographical knowledge, based on sound systematic survey, and, having learned in time the lesson that opportunities once lost may never be recovered, make every effort to take advantage of those that are offered to them. In the expedition against Khiva each column had attached to it an astronomer and small topographical staff, whose duty it was to fix the geographical positions of all camps and map the route and adjacent country, whilst officers on detached duty were instructed to keep itineraries of their routes which might be fitted in to the more accurate survey. On the fall of Khiva an examination of the Khanate was at once commenced, and it was even thought necessary to send Col. Skobelof, disguised as a Turkoman, to survey the route by which Col. Markosof should have reached the oasis. It is much to be regretted in the interests of geography that some such system was not adopted during the recent operations on the Gold Coast, and that so little, comparatively speaking, has been added to our knowledge of Ashantee and the protectorate. The conclusion of peace with King Coffee, and the effect that must have been produced on the inland tribes by the destruction of Coomassie, appear to offer facilities for the examination of a new and interesting region which it is to be hoped will not be neglected by those who are able and willing to take part in the arduous task of African exploration.

The most important military contributions to geography have undoubtedly been those great topographical surveys which are either completed or in progress in every country in Europe except Spain, Turkey, and Greece. Frederick the Great was, I believe, the first to recognise that in planning or conducting operations on a large scale, as well as directing many movements on the field of battle, a commander should have before him a detailed delineation of the ground of a whole or part of the theatre of war. To supply this want, Frederick originated military topography, which, in its narrower sense, may be defined as the art of representing ground on a large scale in aid of military operations. It was found, however, that during war there was rarely sufficient time to construct maps giving the requisite information, and thus the necessity arose of collecting in peace such data as would enable maps to be prepared. In this necessity may be seen the origin of all national topographical surveys, including our own, which was commenced as a purely military survey in 1784 by General Roy, and transferred in 1791 to the old Board of Ordnance. The gradual development of these surveys, and the various stages through which they have passed before reaching their present state of excellence, need not be noticed here. Side by side with the large establishments engaged in the production of the topographical maps, there have grown up in most countries extensive departments, sometimes employing from fifty to sixty officers, whose duty it is to supplement the maps of their own and foreign countries by the collection of all information of whatever nature that may be useful in time of war. The brief interval that elapses between the declaration of war and the commencement of hostilities, the rapid movements of armies, and the short duration of campaigns at the present, have shown more clearly than ever the imperative necessity of previous preparation for war; and the publication of the great surveys of most European countries has given an impetus heretofore unknown to the studies I have alluded to.

The progress of the European surveys, and especially of our own, has been marked by many results which have indirectly influenced the advancement of geographical science. Such are the improvements in instruments made during the progress of the triangulation; the introduction of the Drummond light, Colby's compensating bars, &c.; the connection of the English and Continental systems of triangulation; the pendulum observations at various places; the measurement of arcs of the meridian; the comparison of the standards of length of foreign countries, of India, Australia, and the Cape of Good Hope, with our standard yard, which has recently been completed at the Ordnance Survey Office, Southampton. In the same category may be placed the improvements in the art of map engraving, in the application of chromo-lithography to the production of maps as exemplified in the Dutch process of Col. Bessier and the Belgian maps; and the employment of electrotyping to obtain duplicates of the original plates. The method of copying maps by photography without any error in scale, or any distortion that can be detected by the most rigid examination, was first proved to be practicable and was adopted in the Ordnance Survey Department in 1854, by Major-General Sir Henry James, for the purpose of facilitating the publication of the Government maps of the United Kingdom on the various scales. Since that date the necessity of rapidly producing, multiplying, enlarging, and reducing maps has tended towards the development of the various photographic processes which have been brought to such a high state of perfection. During the last five years photographic negatives on glass covering an area of 10,071 square feet were produced at the Ordnance Survey Office for map-making purposes alone, and from these negatives 21,760 square feet of silver prints were prepared and used in the various stages of the Survey. An area of 959 square feet of the negatives was also used in producing 13,595 maps on various scales by the photosincographic process, which was also introduced by Major-General Sir Henry James. It was by similar processes that the Germans were enabled to provide the enormous number of copies of the various sheets of the map of France required during the war of 1870-1. Any comparison of the maps of various countries would necessarily occupy much time, so I will only add that as specimens of engraving the sheets of our one-inch map are unrivalled, and that no foreign maps can compare for accuracy of detail and beauty of execution with the sheets of our six-inch survey. Our great national Survey is the most mathematically accurate in Europe, and it speaks much for the ability of the officers who have brought it to its present state of perfection, that from the very first they recognised the necessity of extreme scientific accuracy in their work, and that they have never had to withdraw from the position they have taken up with regard to the many questions of detail that have arisen from time to time.

Before concluding this portion of my address I would draw your attention to the appliances used in the minor schools of this country for teaching geography, as they would seem to need some improvement. The appliances to which I allude are models or relief maps, wall maps, atlases, and globes. The use of models as a means of conveying geographical instruction has been too much neglected in our schools. If anyone considers the difficulty a pupil has in understanding the drawing of a steam-engine, and the ease with which he grasps the meaning of the working model, and how from studying the model and comparing it with the drawing he gradually learns to comprehend the latter, he will see that a model of ground may be used in a similar manner to teach the reading of a map of the same area. Relief maps of large areas on a small scale have their uses, but they are unsuitable for educational purposes on account of the manner in which heights must be exaggerated to make them appear at all; this objection, however, does not apply to models of limited areas on a sufficient scale, which always give a truthful and effective representation of the ground. One reason why models have not been more used has been their cost, but the means of constructing them with ease, rapidity, and at slight expense, are quickly accumulating as the six-inch contoured sheets of the Ordnance Survey are published. Instruction in geography should begin at home, and I would suggest that as the six-inch survey progresses each decent school throughout the country should be provided with a model and a map of the district in which it is situated. If this were done, the pupils would soon learn to read the model, and having once succeeded in doing this, it would not be long before they were able to understand the conventional manner in which topographical features are represented on a plane surface, and acquire the power of reading not only the map of their own neighbourhood, but any map which was placed before them. In our wall maps I think we have been too much inclined to pay attention to the boundaries of countries, and to neglect the general features of the ground. It is difficult to say whether the maps have followed the teachers or the teachers the maps, but I fear instruction in physical geography too often comes after that in political geography, instead of a knowledge of the latter being based on a knowledge of the physical features of the earth. My meaning may perhaps be explained by reference to a wall map probably well known to everyone, that of Palestine, which frequently disfigures rather than ornaments the walls of our schoolrooms. In this map there are usually deep shades of red, yellow, and green to distinguish the districts of Judea, Samaria, and Galilee, and perhaps another colour for the Trans-Jordanic region, with a number of Bible names inserted on the surface, whilst the natural features are quite subordinate, and sometimes not even indicated. There is perhaps no book that bears the impress of the country in which it was written so strongly as the Bible; but it is quite impossible for a teacher to enable his pupils to realise what that country is with the maps at present at his disposal. The first object of a wall map should be to show the geographical features of countries, not their boundaries, and for this purpose details should be omitted, and the grander features have special attention paid to them. In school atlases the same fault may be traced, physical features being too often made subordinate to political divisions; and there is also in many cases a tendency to overcrowd the maps with a multitude of names which only serve to confuse the pupil and divert his attention from the main points. The use of globes in our schools should be encouraged as much as possible, as there are many physical phenomena which cannot well be explained without them, and they offer far better means of conveying a knowledge of the relative positions of the various countries, seas, &c., than any maps. The great expense of globes has hitherto prevented their very general use, but some experiments are at present being made with a view to lessening the cost of the construction, which it is hoped may be successful. I cannot pass from this subject without alluding to that class of maps which gives life to the large volumes of statistics which are accumulating with such rapidity. On the Continent these maps are employed to an extent unknown in this country, both for purposes of reference and education, and they convey their information in a simple and effective manner.

I will only detain you to notice briefly a few of the most important geographical events of the year, and foremost amongst these ranks the publication of Dr. Schweinfurth's work which every one has recently been reading with so much interest and pleasure. Dr. Schweinfurth, who received the Founder's medal of the Royal Geographical Society this year, is, I am happy to say, amongst us at present, and has contributed a valuable paper on the oases of the Libyan Desert.

Lieut. Cameron, R.N., has reached Ujiji, and extracts from a journal which he has sent home will be read to you. The observations which he has made are of high value, and the presence of a trained surveyor on the shores of Lake Tanganyika cannot fail to be followed by great results. A short report of Dr. Nachtigall's travels has been prepared for this Section; and Dr. Rowe, who acted as Chief of the Staff to Sir John Glover during his recent operations on the Gold Coast, will read an interesting paper on the country passed through on the march to Coomassie and thence to the coast. Two Engineer officers, Lieuts. Watson and Chippendale, have recently left England to join Col. Gordon at Gondokoro, with the special object of surveying the territory over which Col. Gordon has been appointed Governor by the Khedive. In Algeria the French have been actively engaged on the survey of the country, and the exact level of the Choltmil-Rhir has been determined. Mr. Stanley's second expedition to the east coast of Africa, under the auspices of an English and American newspaper, should not remain unnoticed, and I cannot pass from Africa without expressing my deep regret at the death of Dr. Beke, whose travels in Abyssinia were rewarded by the gold medal of the society, and whose observations in that country were, for their great accuracy, of so much service during the Abyssinian war.

The survey of Palestine, a work which has been said by a distinguished German geographer to mark the commencement of a new era in geographical research, is progressing favourably, and has led to the formation of an American society for the exploration of the country east of Jordan, and of a German society for the exploration of Phœnicia. The Rev. Dr. Porter, from whose labours in Palestine everyone who has visited or takes an interest in the country has derived so much profit and pleasure, will read a paper on the lesser known parts of Eastern Palestine, which he has recently visited ; and a paper on the progress of the survey has been prepared by Lieut. Conder, R.E., the officer in charge. Our own survey is, I regret to say, languishing for want of funds, whilst that of the Americans is receiving that support from the people which it deserves ; the serious loss which the fund has experienced in the death of Mr. Drake, who recently succumbed to an attack of fever at Jerusalem, and who had previously devoted his best energies to the work, must be still fresh in your memories. Lieut. Gill, R.E., who accompanied Col. V Baker last year on a tour to Meshed, and the head waters of the Atrek, has prepared an account of their journey. Some most interesting particulars of the visit of a portion of Mr. Forsyth's mission to the Great Pamir and Wakham have been kindly supplied by Col. Biddulph, R.A., from letters received from his brother, Capt. Biddulph. The success of the party has, however, been purchased by the loss of Dr. Stoliczka, who died from the effects of fatigue and exposure within a few marches of Leh. Mr. Delmar Morgan has prepared a very valuable paper on Russian travels in Central Asia in the 15th century. Mr. MacGahan, the correspondent of the *New York Herald*, whose remarkable journey across the Desert to join General Kaufmann's column when marching on Khiva astonished the Russians, has forwarded some interesting notes on the Russian expedition against Khiva.

In Australia the great geographical event of the year has been Col. Warburton's journey from Alice Springs, near Mount Stuart, on the line of overland telegraph, to Roebourne, in Nichol Bay, for which he was awarded the Patron's gold medal of the Royal Geographical Society. Such particulars of the journey as have been forwarded to me through the courtesy of the Colonial Office and of Mr. Dutton, the Agent-General for South Australia, will be communicated to you.

In America, whilst the coast and inland surveys have been progressing, Dr. Haydon, who was the first to disclose to us the strange beauties of the Yellowstone region, has been engaged in exploring a country equally wild and picturesque, the eastern half of Colorado. Other exhibitions have been doing good service in the Yellowstone country, Arizona, Oregon, and the Aleutian Islands, amongst them one sent out by Yale College, which, besides exploring new country, brought back five tons of specimens from the great fossil beds of Oregon and other places for the college museum. I cannot help thinking that in sending out these expeditions—for this is only one of a series—for the examination of the geography, geology, botany, zoology, &c., of some special district, Yale College has set an example which might well be followed by our own universities, and that Dublin, Oxford, and Cambridge might take more part than they have hitherto done in what may be called scientific exploration in the field. My old friend and fellow-traveller, Capt. Anderson, R.E., has been engaged as chief astronomer of the International Boundary Commission in running the 49th parallel through the unknown country between the Missouri and Saskatchewan, and a short account of the demarcation of the parallel and the country it passes through will be read to you. In the south, Commanders Lull and Selfridge have found practicable routes for ship canals from Greytown, by Lake Nicaragua, to Brito, on the Pacific, and by way of the Atrato, from the Gulf of Darien, to a point near Cupica, on the Pacific ; the cost of the latter is estimated at twelve million pounds. In South America Prof. Orton has been extending our knowledge of the Amazon country ; and I may mention the activity which the Peruvian Government is showing in promoting the exploration of the little-known districts of Peru. Mr. Hutchinson, late her Majesty's Consul at Callao, has forwarded a paper on the commercial, industrial, and natural resources of Peru, which will be found to give much interesting information on that country.

Dr. Carpenter will, I hope, give us some account of the cruise of her Majesty's ship *Challenger*, which cannot fail to interest the people of this town, from Prof. Wyville Thomson's former connection with it. Capt. Warren, R.E., whose name is so well known from his work at Jerusalem, has forwarded a valuable paper on reconnaissance in unknown countries ; and Capt. Abney, R.E., will read one on a subject which he has made peculiarly his own—the application of photography to military purposes. M. Maznoir, the secretary of the French Geographical Society, has forwarded a paper on the objects sought to be obtained by the International Congress to be held at Paris in the spring of next year.

I regret that I am not able to give any definite information on the probability of Government assistance to Arctic exploration, but I understand that the impression produced on the members of the deputation which recently had an interview with the Prime Minister on the subject was that he was not unfavourable to such assistance. Admiral Sherard Osborn has kindly forwarded a paper on routes to the north pole, and Lieut. Chermside, R.E., who accompanied Mr. Leigh Smith on a very remarkable voyage last year to Spitzbergen, will read an account of the discoveries they were enabled to make. The reports of the officers of the *Polaris* have been published, expressing contradictory opinions as to the possibility of their having been able to reach a higher latitude. As regards the general subject of Arctic exploration, there can, I think, be no doubt that that by Smith's Sound would yield the most important scientific results, and would offer great facilities for reaching the Pole itself. It should not be forgotten that all recent Polar expeditions sent out from this country have been despatched with the special object of ascertaining the fate of Sir John Franklin, and that discovery was not a principal object. When, too, we consider that in these expeditions Arctic travel was reduced to a very perfect system, that the distance from the point reached by the *Polaris* to the Pole is less than has already been performed in some of the sledge journeys, and that no life has ever been lost on a sledge journey, it is impossible to doubt that a well-organised expedition would be able to reach the Polar area. In the words of a well-known Arctic explorer, "What remains to be done is a mere fleabite to what has already been accomplished." Morton, the second mate of the *Polaris*, says, as the result of his third voyage, that he is more than ever convinced of the practicability and possibility of reaching the Pole ; and if I may express my own opinion, it would be in the words attached to a picture at the last exhibition of the Academy in London, "It is to be done, and England ought to do it."

Reports.

Report on the Rainfall of the British Isles for the years 1873–74.

We extract from the report the part relating to the rainfall of the British Isles during the years 1872–73. The very exceptional character of the rainfall of 1872 was mentioned in our last report, but in accordance with a custom which has now prevailed for twelve years, it was only incidentally referred to, the details being deferred until the two years 1872 and 1873 could be published together. This course, which was originally adopted with a view to economy in printing, has in the present instance had the fortunate result of bringing together two very remarkable features of each, of which we must speak separately.

Rainfall of 1872.—Records of rainfall have been collected and discussed in our previous reports, which enable us to compare the total fall in any year from 1726 to the present time with the mean fall. One of these tables (that facing p. 286 Brit. Ass. Report 1866) contains nine long registers, extending over 140 consecutive years, but the greatest excess even at a single station was only 58 per cent. (at Oxford in 1852). In 1872 this value was largely exceeded at a number of stations, as is shown by Tables I. and II., whence it appears that at fourteen stations out of 115, or 12 per cent., it exceeded this previously unparalleled value. At thirteen the excess was greater than 60 per cent., and it reached or exceeded 70 per cent. at the following stations:—

Shropshire, Shiffnall	Rainfall	77	per cent. above average	1860–69.
" Shrewsbury	"	75	"	"
" Hengoed, Oswestry	"	70	"	"
Northumberland, Bywell	"	77	"	"
Haddingtonshire, East Linton	"	70	"	"
Aberdeenshire, Braemar	"	78	"	"

No similar falls have occurred since 1726, and there is no evidence of such a fall since rainfall observations were commenced, nearly two centuries ago. Full details respecting the monthly fall of rain in this very remarkable year are given in the appendix to this report, and we think it may be regarded as fortunate that so remarkable a fall has occurred at a period when, owing largely to the operation of this committee, the system of observation is in a state unprecedentedly near perfection.

The Rainfall of 1873.—If this year had stood by itself it would merely have been classed as a rather dry year, and would have soon passed into oblivion. Coming, however, immediately after such an exceptionally wet year, it has produced the unusual result of giving two consecutive years, one with twice the rainfall of the other, and in many instances with much more than twice. How rare is this occurrence may be judged from the fact that there is no case in the 140 years' table just referred to. The nearest approaches are—Chatsworth, in 1788, 19·86 inches, in 1789, 36·31, the former being 55 per cent. of the latter. A still nearer approach occurred at Cobham, in Surrey, in 1851 and 1852, when the totals were 17·38 and 34·19 inches respectively, the former being 51 per cent. of the latter. In Table II. no cases are admitted unless much more striking than the above. The districts in which these exceptional ratios occur are (as might be expected) principally those in which the excess in 1872 was greatest, but there are also a few of which the explanation is not so obvious. It is very satisfactory to feel that these two exceptional years have found in the British Isles the most nearly perfect system of observation in the world.

Your committee cannot close their report without expressing as far as words can do so the loss which they have sustained in the death of Prof. Phillips, one of the original members appointed in 1865, who, notwithstanding the numerous other demands upon his time, was always as willing as he was able to assist the committee in any of the various difficulties which the extent of their operations inevitably involve.

Preliminary Report on Dredging on the Coast of Durham and North Yorkshire.

The dredging off the coasts of Durham and North Yorkshire, provided for by a grant from the British Association last year, was carried out during the week beginning on the 13th July. A suitable vessel was engaged, and being on the whole favoured by the weather, we dredged every day until the 18th inclusive. During two days the R.A. M. Marman accompanied us. We were indebted to him for valuable assistance in naming some of our specimens, as well as for kindly undertaking to report on some sections of the work.

On two days out of the six the sea was too rough to allow of the dredges being worked very successfully, and one dredge was unfortunately lost by getting fast on hard ground while a very strong tide was running, but with these exceptions the work was carried out satisfactorily. The dredging ranged from near Tynemouth, on the north, to Scarborough, on the south, the water varying in depth from 20 to 45 fathoms, the greater portion of the time being devoted to a belt known to fishermen as the "inner fishing bank," lying from four to eight miles from the shore. One day, however, was spent at the greater distance of thirty to forty miles from shore, and another day at a distance of about seventeen miles.

Time has not allowed of anything more than safely to preserve and arrange our captures. On a future occasion we hope to give a full account of the results obtained.

NOTES

THE final programme of the Oriental Congress, to be held in London next month, was settled on Tuesday; we hope to be able to say something about it next week.

M. ALLUARD, director of the Meteorological Observatory which is being erected on the Puy-de-Dôme, regrets that, owing to the backward state of the works, the building cannot be opened in the end of September, as was expected. It is hoped, however, that the work of the Observatory will be commenced before winter. The construction of the telegraphic line which will connect the station on the plain at Clermont with the station on the summit of the Puy-de-Dôme has been completed. The formal inauguration will take place next summer. One main cause of the delay is owing to the fabulous prices demanded by the small proprietors through whose lands the approaches to the Observatory must be made; no blame whatever for the delay can be attached to the staff of the Observatory. The Government authorities, central and local, have shown the greatest zeal in forwarding the construction of the works.

THE Emperor of Austria has conferred the decoration of Knight of the Order of the Iron Crown, with a patent of hereditary nobility, on Dr. Julius von Haast, director of the Museum of Canterbury, New Zealand, in recognition of his eminent scientific merits and attainments.

SIR WILLIAM FAIRBAIRN, Bart., F.R.S., died on the 18th inst., in his eighty-fifth year, having been born at Kelso, in Scotland, in 1789. What Sir William has done to improve the manufacture of iron is well known. He was one of the founders of the British Association, and was its president in 1861. Many papers by Sir William appeared in the Philosophical Transactions, in the Reports of the British Association, and in the Transactions of the Philosophical Society of Manchester. Some of his works, however, were also published separately. Among his chief productions may be specified treatises on "Canal Navigation," on "The Strength and other Properties of Hot and Cold Blast Iron," on "The Strength of Locomotive Boilers," on "The Strength of Iron at Different Temperatures," on "The Effect of Repeated Melting upon the Strength of Cast Iron," on "The Irons of Great Britain," on "The Strength of Iron Plates and Riveted Joints," on "The Application of Iron to Building Purposes in General," on "Useful Information for Engineers," &c.

IT is stated that the Crown has appointed Mr. John Ferguson, M.A., to the chair of Chemistry in Glasgow University, vacant by the retirement of Dr. Thomas Anderson.

THE subscriptions announced up to Saturday last on behalf of the University of Edinburgh Buildings Extension Scheme amount to 69,017*l*. The total sum required from the public is 100,000*l*.

THE Council of the Ray Society, in presenting their Thirty-first Annual Report, congratulate the members on the continued prosperity of the Society. The arrears in the issue of the annual volumes, long a cause of much inconvenience, have been at length overcome. Since the last meeting, at Bradford, two volumes, those for the years 1872 and 1873, have been distributed; a third volume, that for the year 1874, is finished, and will be issued in October. The volumes for the years 1872 and 1873, consisting of the first part of the British Annelids, by Dr. McIntosh, although containing less text and fewer illustrations than in some of the previous memoirs, have been in the matter of production equally costly. The very beautiful plates, printed in colours by lithography, required many stones for their proper development, and necessitated a corresponding outlay. The volume for the present year, on the Spongiadæ, by Dr. Bowerbank, completing the series on that subject, and, illustrated by ninety-two plates, is also a most excellent example of work both on the part of the artist and the lithographer. As the cost of this volume has been in excess of the yearly income, it is hoped that a considerable addition of subscribers will justify the money expended. The proposition alluded to in the last Report, viz., that of reducing the price of certain of the earlier works of the Society, has been much appreciated by the members, and has proved a financial success. It has been suggested that the machinery of the Society might be more largely employed in the production of Monographs on the Fauna and Flora of Great Britain; the Council therefore solicit assistance from authors who possess the requisite knowledge and who may be willing to assist in the undertaking. In conclusion, the Council, in order to obtain funds sufficient to carry out the objects of the Society, urge upon members the necessity of gaining new subscribers.

IN an address recently delivered before the Dublin Obstetrical Society, Dr. Evory Kennedy discussed the development and spread of scrofula from an evolutionary point of view. This is an aspect of hereditary disease which admits of much extension; one which requires a much larger accumulation of statistics than we yet possess, and a far deeper insight into the physiological basis of pathology than we can expect for some time to come. There is one argument brought forward by Dr. Kennedy that deserves especial attention, which is, that as scrofula tends to early death, or the production of a few early dying offspring, the fact that it is not diminishing in its ravages proves that it is being continually developed *de novo* by surrounding circumstances. Is this not a sufficient stimulus for increased sanitary legislation?

THE Governor of Minnesota has called on the general Government for aid, as, owing to the ravages of grasshoppers for two years past, many thousands are suffering for want of food. The American naturalists suggest that the grasshopper should be eaten, just as it is in portions of Africa and Western Asia.

The new Minister of Public Instruction visited the Observatory of Paris last week, and expressed his satisfaction to M. Leverrier with what he had seen and with the explanations which had been given to him.

THE ownership of the grounds between the old Paris Observatory Gardens and the Boulevard Arago, more than two acres has been disputed between the Government and the city of Paris. The right of the city was acknowledged, but the Municipal Council have let it to the Observatory for the nominal rent of 20 francs a year. On these grounds a magnetic service is to be established.

Two interesting balloon ascents have taken place in America lately, one at New York by Prof. Donaldson, with his large Transatlantic balloon, and a batch of reporters from several influential papers at New York. The trip, including four landings, lasted more than twenty-four hours, and ended in the vicinity of Saratoga, the balloon having run a distance of about eighty miles. A few days afterwards Prof. Wyse executed an ascent in Canada, in order to ascertain if a western current blows in the upper parts of the atmosphere when the lower stream of air is running in another direction. At a moderate height the western current was met with. Prof. Donaldson contends that it is a consequence of the revolution of the earth, and can be trusted to for crossing the Atlantic from America to Europe. But can these partial experiments be really relied upon? That remains to be demonstrated.

ONE of the very few scientific members of the Versailles Assembly has departed. M. Fland, an engineer, died at Dinan, where he was appointed Mayor seventeen years ago. He had an engine manufactory at Brest, and was appointed by contract the constructor of the celebrated Giffard injector. M. Fland was originally a pupil of the Ecole des Arts et Métiers d'Angers.

MR. THOMAS MUIR, M.A., F.R.S.E., Assistant Professor of Mathematics in the University of Glasgow, and author of some original investigations in Mathematics, has been appointed successor to Dr. Bryce in the Mathematical Mastership of the High School of Glasgow.

MR. CHARLES MOORE, the *Garden* states, who recently brought a good many valuable and very novel plants to this country from the South Sea Islands and Australia, returns to Sydney by the next mail, having visited many of the best botanic gardens and nurseries in Europe, and selected an immense collection of valuable and rare plants for the Sydney Botanic Garden, which is said to be one of the most beautiful in the world.

WE learn from *Iron* that the Academy of Sciences of Berlin offers a prize of 200 dols., payable in July 1876, for the best essay recording experiments as to whether changes in the hardness and friability of steel are due to chemical or physical causes, or to both. Papers in German, Latin, English, or French, are to be sent in before March 1876.

THE Report of the Council of the Leicester Literary and Philosophical Society, presented at the annual meeting of June 15 last, is on the whole very gratifying. The Society contains a large number of members, and is working in the right direction in trying to interest not only the members, but the inhabitants of Leicester generally, in science as well as literature. During last winter a very judiciously planned course of lectures was delivered in connection with the Society, which was fairly attended, and would, we believe, have been still better attended, had there been no free seats. The Society is divided into sections, three of which are scientific—(1) Meteorology and General Physics, (2) Geology and Palæontology, (3) Natural History. Satisfactory reports are given in Nos. 1 and 3, the latter having set itself to the collection of statistics of the natural history of the county, and the former, among other things, to a regular series of meteorological observations. We hope the Leicester Society will persevere in its work.

WE have received as No. 1 of the "Proceedings of the Chester Society of Natural Science," a very excellent list (with remarks) of birds observed in Werral, Cheshire, by J. F. Brockholes. The list contains 168 species.

THE Seventh Annual Report of the Trustees of the Peabody Museum of American Archæology and Ethnology (Harvard) contains some account of the valuable series of objects connected with South American and Pacific archæology and ethnology, which the late Prof. Agassiz acquired during his voyage in the *Hassler* in 1871-2, and which have been transferred to the Peabody Museum. The collection is very valuable and comprehensive; there are 330 specimens of Peruvian skulls alone. The Report contains a very ingenious paper, apparently by Mr. J. Wyman, the Curator, On the human remains in the shell heaps of the St. John's River, East Florida, in which the author argues, from the condition of the bones and other circumstances, that the Floridan aborigines were in all probability cannibals.

ONE of the many valuable results of the work of the U.S. Geological Survey of the Territories, is a "Synopsis of the Flora of Colorado," by T. C. Porter and J. M. Coulter. This work is intended to be a type of a series of handbooks of different branches of natural history, to be published from time to time as a part of a series of "Miscellaneous Publications" for the use of students. No. 3 of the series is nearly ready, and has been prepared by the eminent ornithologist, Dr. E. Coues. It will form an octavo volume of several hundred pages, bringing the whole subject of western ornithology up to date.

A PAPER by Dr. H. D. Schmidt, of New Orleans, U.S.A., On the construction of the dark or double-bordered nerve-fibre, occupies a large part of the last number of the *Microscopic Journal*, and is illustrated by three plates. In the same number is the first instalment of a communication by Rev. S. J. Brakey on the theory of immersion.

THE additions to the Zoological Society's Gardens during the past week include two Chukar Partridges (*Cacabis chukar*) from N. W. India, presented by the Hon. Justice Jackson; four Sandwich Terns (*Sterna cantiaca*), four Avocets (*Recurvirostra avocetta*), European, purchased; a Common Crowned Pigeon (*Goura coronata*), two Bronze-winged Pigeons (*Phaps chalcoptera*), hatched in the Gardens; a Black-eared Marmoset (*Hapale penicillata*) from Brazil; and two Suricates (*Suricata zenik*) from South America, deposited.

FRENCH ASSOCIATION FOR THE PROGRESS OF SCIENCE

THE Lille Session was opened on Aug. 20 by the address of M. Wurtz, of which you have received a copy, and which has been published in all the French papers. The *Débats*, by an extraordinary access of zeal, published it a day before it was delivered!

On Friday Colonel Laussedat read at a general session a report on the results of the last session.

On Saturday evening a lecture on the Transit of Venus was delivered by M. Faye, before a very large audience at the Cercle du Nord, a magnificent building, richly fitted up. The accomplished astronomer referred mostly to the arrangements at the French stations, deeply regretting that all civilised nations had not been united into a kind of federation for working in combination at a problem of such magnitude; he hopes that it will be so in 1882. He insisted upon the importance of photography, which has been used to such good purpose by the Americans, and he trusts that in future times photography will take the lead in such observations. He gave interesting details as to the Yokohama station, to which a Japanese prince educated in France will be attached as a photographer. The consequence will be that M. Jannsen and his associates will be admitted into the interior sea of Japan, where, up to the present moment, not a single foreign vessel has ever sailed.

Owing to the coincidence of the meeting of the British Association at Belfast, scarcely any English *savans* are present here. The only British member I have seen up to the present moment is Dr. Sylvester, the celebrated mathematician. He has been nominated the honorary president of his section, the acting president being M. Catalan, who, though a Frenchman, is regarded as a representative of Belgium. Ten years ago he settled in Liége, where he is a professor in the University.

The interest felt by the people generally is not nearly so great as in the case of the British Association in England. The inhabitants of the city do not appear to understand fully the extent of the honour conferred on them. A *train de plaisir* has been organised to visit distant workshops, but Lille workshops have not been opened for inspection.

Newspapers are glad to publish the transactions of the several sections, but the Association has not authorised any one of them to publish them at full length.

Last Saturday a most interesting experiment was tried with success on the Northern line. M. Giffard, the inventor of the injector, has constructed a new waggon which is suspended by powerful springs at both extremities, thus completely avoiding oscillation. It is very easy to read and even to write in these new carriages. The invention will be exhibited very shortly to the English public. W. DE FONVIELLE

Lille, Aug. 23

OPENING ADDRESS BY THE PRESIDENT, M. WURTZ, AT THE MEETING OF THE FRENCH ASSOCIATION

The Theory of Atoms in the General Conception of the Universe

FRANCIS BACON conceived the idea of a society of men devoted to the culture of science. In his "New Atlantis," in which he describes the organisation of this society and its influence upon the destinies of a wisely governed people, he shows it rising to the dignity of a State institution. The progress of civilisation by the search for truth, and truth discovered in the order of nature by experiment and observation—such are the ends proposed and the means made use of. Thus, in an age when the syllogism was still supreme, and which was firmly held beneath the scholastic yoke, the English Chancellor assigned to science at once its true method and its mission in the world.

The plan of Bacon embraced all branches of human knowledge. The land was overrun by a multitude of observers, engaged, some in studying the monuments of the past, the language, the manners, the history of the nations; others in observing the configuration and the productions of the soil, noting the superficial structure of the globe and the traces of its revolutions, collecting all the data concerning nature, the organisation and distribution of plants and animals. Other men, located in various regions, cultivated the exact sciences. Towers were constructed for the observation of stars and meteors; vast edifices, arranged for the study of physical and mechanical laws, contained machines which supplied the deficiency of our forces, and instruments which added to the precision of the senses and rendered abstract demonstrations sensible. This immense labour was uninterrupted, co-ordinated, controlled; it had its origin in self-abnegation, it was regulated by precision, and had time for its sanction. Thus was it fruitful.

Such was the idea of Francis Bacon. To observe all things; by the rational comparison of these observations to disclose the hidden connections of phenomena, and to rise by induction to the discovery of their real nature and their causes, all with the view "of extending the empire of man over entire nature, and of executing everything possible for him to do;" such is the object which he has pointed out to us; such is the function of science.

This great exploration of the earth which he desired to institute, this patient and exact research of the laws of the universe, this deliberate intervention of science in the affairs of life and of the universe,—could all this be the work of his own time? He knew it too well to venture to hope it himself, and it is on this account, doubtless, that he placed the fortunate country which enjoyed so noble an institution in the solitude of the great ocean.

Two centuries and a half ago the conception of Bacon was regarded as a noble utopia; to-day it is a reality. That magnificent programme which he then drew out, is ours, gentlemen; ours, not in the narrow sense of the word, for I extend this programme to all who, in modern times and in all countries, give themselves to the search for truth, to all workers in science, humble or great, obscure or famous, who form in reality, in all parts of the globe and without distinction of nationality, that vast association which was the dream of Francis Bacon. Yes, science is now a neutral field, a commonwealth, placed in a serene region, far above the political arena, inaccessible, I wish I could say, to the strifes of parties and of peoples; in a word, this property is the patrimony of humanity. It is, too, the principal conquest of this century, which my illustrious predecessor characterised, with so much justice, as the century of science.

Modern generations are spectators, indeed, of a magnificent spectacle. For a century past the human mind has directed an immense effort to the study of the phenomena and the laws of the physical universe. Hence an astonishing development of all the sciences founded on observation and experiment. New ideas which have arisen in our days in the correlation and conservation of forces have been like a revelation to some of these sciences. Mechanics, physics, chemistry, physiology itself, have found at once a *point d'appui* and a bond of connection. And this powerful flight of ideas has been sustained by the progress of the methods, I should say by the more careful exactness of observations, the perfect delicacy of experiments, the more rigorous severity of deductions. These are the springs of this movement which hurry along the sciences, and of which we are the astonished and moved witnesses. It is to propagate it broadcast over our country that we hold, each year, this parliament, to which are invited all who take part or are interested in the war against the unknown. Science is indeed a war against the unknown; for, if in literature it is enough to give expression, and in art a body, to conceptions or beauties deposited either in the human mind or in nature, it is not so in science, where truth is deeply hidden. She must be conquered, she must be stolen, like the Promethean fire.

It is of some of these conquests that I wish to speak to-day, full of doubt and apprehension in presence of so great a task. To respond to the demands of his position and to follow noble examples, your president ought, at the beginning of this session and of the ceremonies which inaugurate our young association, to trace the progress accomplished in the sciences, mark by a few bold lines the various routes over which it has recently run, and the culminating points which it has attained. I shrink from such a programme: if it does not exceed the powers of some of my colleagues, and doubtless of some among you, it greatly surpasses mine. Less justified and less daring than was Condorcet at the end of last century, I only perceive the outlines and some bright patches of the sketch which he attempted to draw; and to see it accomplished, I shall call to my assistance those who will follow me in the honourable and perilous post I now occupy.

I shall confine myself, then, gentlemen, to speaking to you of what I know, or of what I think I know, by directing your attention to the science to which I have devoted my life.

Chemistry has not merely grown, it has been regenerated since Lavoisier. You know the work of that immortal master. His labours in connection with combustion gave to our science an immovable basis by fixing at once the notion of simple bodies and the essential character of chemical combinations. In these latter we find in weight all that is ponderable in their elements. These, in uniting to form compound bodies, do not lose any of their proper substance; they lose only an imponderable thing, the heat disengaged at the moment of combination. Hence that conception of Lavoisier that a simple body such as oxygen is constituted, properly speaking, by the intimate union of the ponderable matter oxygen with the imponderable fluid which constitutes the principle of heat, and which he named caloric—a profound conception, which modern science has adopted, giving it a different form. It is, then, unjust that, in recent times, Lavoisier should be accused of having misconceived what is physical in the phenomenon of combustion, and that an attempt should be made to rehabilitate the doctrine of Phlogiston which he had the honour of overturning. It is true that in burning bodies lose something: "It is the combustible principle," said the partisans of Phlogiston; "It is caloric," said Lavoisier; and he adds, an essential thing, that they gain in oxygen.

Thus Lavoisier perceived completely the phenomenon, of which the great author of the phlogiston theory, G. E. Stahl, had only a glimpse of the external appearances, and of which he misconceived the characteristic feature. Such is, gentlemen, I maintain, the foundation and the origin of modern chemistry. Is that to say that the monument raised upon these bases by Lavoisier and his contemporaries subsists in all its parts, and that it was accomplished at the end of last century? It would not be from want of materials, and even in its outlines we may notice lines which have in time disappeared. It has then been added to and in part transformed; but it still rests upon the same foundations. Such has been in all sciences and in all times the lot of theoretical conceptions; the best of them contain obscurities and gaps which, on disappearing, become the occasion of important developments or of a new generalisation.

That of Lavoisier embraced especially the bodies best known in his time, *i.e.*, the compounds of oxygen, the true nature of which was discovered by him in his researches on combustion. All these bodies are formed of two elements; their constitution is binary, but it is more or less complicated. Some, oxides or acids, contain a simple body united to oxygen; others, more complex, are formed by the combination of acids and oxides among themselves, a combination which gives rise to salts. These last then are formed of two constituent parts, each of which contains oxygen united to a simple body. Such is the formula of Lavoisier on the constitution of salts; it is in harmony with the fundamental idea which he enounced on chemical combination, an idea according to which all compound bodies are formed of two immediate elements, which are either simple bodies or themselves compound bodies.

This dualistic hypothesis was embodied, in his time and with his consent, in French nomenclature, the work of Guyton de Morveau, the principle of which may be thus summarised: two words to designate each compound, one to mark the genus, the other the species. Thus, one of the fundamental conceptions of the system of Lavoisier—dualism in combinations—found a striking expression in the binary structure of the names, and is, as it were, insinuated into the mind by the very terms of chemical language; and we know what is, in such a case, the power of words.

The great successor of Lavoisier, Berzelius, extended to the whole of chemistry the dualistic hypothesis of Lavoisier on the constitution of salts. Wishing to give it a solid support, he added to it the electro-chemical hypothesis. All bodies are formed of two constituent parts, each of which possesses, and is, as it were, animated by, two electric fluids. And as the electro-positive fluid attracts the electro-negative, it is natural, it is necessary that in every chemical compound the two elements should reciprocally attract each other. Is not the one carried towards the other by electric fluids of opposite kinds? We see that the hypothesis of Berzelius gives at once a striking interpretation of the dualism in combinations and a simple and profound theory of chemical affinity. This elective attraction which the final particles of matter exercise upon each other was referred to electric attraction.

Another theoretic conception gave a body to the electro-chemical hypothesis, and has given since a solid basis to chemistry as a whole. We speak of the atomic theory, revived from the Greeks, but which took, at the commencement of this century, a new form and a precise expression. It is due to the penetration of an English thinker, Dalton, a teacher of chemistry in Manchester in the beginning of the century. It was less a pure speculation of the mind, as were the ideas of the ancient atomists and of the philosophers of the Castesian school, than a theoretical representation of well-established facts, viz., the parity of the proportions according to which bodies combine, and the simplicity of the relations which express the multiple combinations between two bodies.

Dalton found, in fact, that, in cases where two substances combine in several proportions, if the quantity of one of them remains constant, the quantities of the other vary according to very simple relations. The discovery of this fact was the starting-point of the atomic theory. Here is the substance of this theory:—That which fills space, viz. matter, is not infinitely divisible, but is composed of a universe of invisible, imperceptible particles, which, nevertheless, possess a real extension and a definite weight. These are atoms. In their infinitely attenuated dimensions, they offer points of application to the physical and chemical forces. They are not all like each other, and the diversity of matter is owing to inherent differences in their nature. Perfectly identical for the same simple body, they differ from one element to another in their relative weights, and perhaps by their form. Affinity sets them in motion, and when two bodies combine with each other, the atoms of the one are drawn towards the atoms of the other. As this approach always takes place in the same manner between a determinate number of atoms, which are in juxtaposition one to one, or one to two, or one to three, or two to three—in other words, according to very simple proportions, but invariable for a given combination—it results therefrom that the smallest particles of this combination present a fixed composition rigorously similar to that of the entire mass.

Thus the most important fact of chemistry, the immutability of the proportions according to which bodies combine, appears as a consequence of the fundamental hypothesis that chemical combinations result from the coming together of atoms possessing invariable weights. Berzelius compared these atoms to minute magnets. He imagined them to have two poles where the two electric fluids are separated but unequally distributed, so that one of them is in excess at one of the poles. "There exists," he said, "atoms with excess of positive fluid and others with excess of negative fluid; the first attract the second, and this attraction, the source of chemical affinity, preserve the atoms under all combinations. At the moment that these last are formed they are set in motion; in the completely formed compound they are at rest, and are divided as if into two camps, at once kept together and maintained in opposition by the two electric fluids of opposite kinds.

Thus the electro-chemical theory, ingeniously adapted to the hypothesis of atoms, raised the dualism of Lavoisier to the dignity of a system, which appeared solidly established during the first half of this century. The facts then known were included in it without difficulty, and the rich materials which the patience or the genius of experimenters amassed without ceasing were very soon co-ordinated.

Without attempting to enumerate the older works relating to the decomposition of alkalis, to the nature of chlorine recognised as a simple body, to various newly-discovered elements, such as selenium, tellurium, iodine, we shall mention in a special manner among so many discoveries, that of cyanogen, which we owe to our own Gay-Lussac. The demonstration of the chemical functions of this compound gas, which behaves like a simple body, which is capable of forming the most varied combinations with true elements, which finally, when it is engaged in such combinations lends itself to double decompositions, as does chlorine in the chlorides, was a great step in the progressive march of science. Hence the definition: cyanogen is a compound radical, and the triumphant appearance of the doctrine of radicals. It had been vaguely intimated by Lavoisier; it really dates from the discovery of cyanogen, and will make a rapid advance. Up to that time great efforts had been directed to the side of inorganic chemistry, and great ideas had arisen in this domain. The application of these ideas to organic chemistry, upon which attention then began to be directed, presented some difficulties.

We know that the innumerable bodies which nature has distributed in the organs of plants and animals contain a small number of elements—carbon, hydrogen, oxygen, and often nitrogen. It is then not in their general composition that they differ, but by the number and arrangement of the atoms which enter into their composition. By increasing more or less and grouping themselves in various manners, these atoms give rise to an immense multitude of distinct compounds which are true chemical species. But what is the arrangement of these atoms? What is the structure of these organic molecules, so much alike in the nature of their elements, so wonderful in the infinite diversity of their properties? Berzelius solved this question without hesitation. Comparing organic compounds to the bodies of inorganic chemistry, he divided both classes of atoms into two lots, grouping on one side carbon and hydrogen, electro-positives, and on the other, oxygen, electro-negative. And when, at a later time, chlorine was artificially introduced into organic compounds, the atoms of this powerful element were ranged on the side of oxygen, both being invariably found in binary combinations of which they formed the electro-negative element, the atoms of carbon and hydrogen constituting the electro-positive radical.

Thus the great promoter of inorganic chemistry attempted to fashion organic molecules according to the image of those molecules of dead matter which he had studied so thoroughly. The paths which Lavoisier traced in this domain he wished to extend to the world of products formed under the influence of life; they resulted in a dead-lock. In proportion as the riches of science increased it was necessary, in order to uphold the system, to accumulate hypotheses, to invent radicals, to construct, with insufficient or imaginary data, formulæ more and more complicated—a thankless task, in which the feeling of experimental realities and sober appreciation of facts often gave place to outrageous reasonings and vague subtleties. These barren efforts of a great mind inaugurated the decline or marked the termination of the dualistic ideas which were at the foundation of what has been called, improperly perhaps, the old chemistry. The new began at that point. Great discoveries, cleverly and boldly interpreted, gave it an impulse which still endures.

There were then—I speak of forty years ago—a number of young men, with Dumas and Liebig at their head, in the opposite camp, who cultivated with ardour the investigation of organic compounds. Convinced that the constitution of these compounds could only be deduced from the attentive investigation of their properties and metamorphoses, they undertook to investigate these bodies themselves, to transform them, to torment them in some sort by the action of the most diverse reagents, in the hope of discovering their intimate structure. And this is, gentlemen, the true method in chemistry; to determine the composition of bodies, and by careful analysis of their properties to fix, as far as possible, the grouping of their ultimate particles. This, then, is the glory of our science, and the single but precious contribution which it is able to furnish for the solution of that eternal problem, the constitution of matter.

From the researches which were made at this epoch and in this spirit, an all-important fact issued; it relates to the action of chlorine on organic compounds. This simple body deprives them of hydrogen and may be substituted for that element, atom for atom, without affecting the molecular equilibrium and without, adds Dumas, modifying the fundamental properties. This proposition encountered at first the most violent contradiction. How could chlorine take the place of hydrogen and play its part in combinations? These two elements, said Berzelius, are endowed with opposite properties, and if the one is lacking the other cannot supply its place; for, in short, they are two inimical brothers, little disposed and by no means fit to be kept in the same house. These critics and many others have not prevailed against facts. The theory of substitutions has come triumphantly out of this great discussion, which marks a date in the history of our science. Its natural development has gradually introduced into it new ideas on the constitution of chemical compounds, on the mode of combination of the elements which they contain.

These ideas have come to light by various ingenious comparisons. Laurent considered organic compounds as formed of nuclei with appendages, both the one and the other admitting into their structures atoms grouped with a certain symmetry. Dumas compared them to edifices of which the atoms constitute, in a manner, the materials. Hence the graphic but frequently correct expression, of molecular edifices capable of being modified, in certain cases, by the substitution of one part for another, and which, in other cases, the shock of powerful reagents may shatter to pieces. In both conceptions the chemical molecules were regarded as forming a whole. A little later Dumas compared them to planetary systems; and here he veritably shot ahead of his time in giving us a glimpse of groups of atoms maintained in equilibrium by affinity, but carried along by movements, as the planets of a solar system are acted upon by gravitation and carried into space. It is in these movements of atoms and molecules that at a later period the source of the physical and chemical forces must be sought for; but I must not anticipate. I have attempted to show how the ideas on chemical combinations have been gradually modified under the double influence of the atomic hypotheses and of facts brought to light by the French school concerning their reciprocal replacement in combinations. Forming a whole, more or less complex, the molecules of organic substances may be modified by substitution and give rise to a multitude of derivatives which naturally attach themselves to the mother substance. The latter serves them as a model or type. The typical idea thus introduced into science very soon occupied a large place. It first brought to it important elements of classification. All the compounds derived by substitution from the same body were ranged in the same family, of which the latter was, so to speak, the chief. Hence arose groups of bodies perfectly distinct from each other, and the number of which were being constantly increased by daily discoveries. It was necessary not only to introduce order into all these tribes, but to connect them with each other by a common bond. The honour of having discovered the superior principle of classification belongs to Laurent and Gerhardt, valiant champions of French science, from whom premature death has snatched, if not victory, at least the gratification of victory. Laurent was the first to say that a certain number of mineral and organic compounds possessed the constitution of water, and this idea, brilliantly developed by Williamson, was generalised by Gerhardt. According to the last named, all inorganic and organic compounds may be connected with a small number of types, of which hydrochloric acid, water, and ammonia, are the chief. In these compounds, relatively simple, one element may be replaced by another element, or by a group of atoms performing the function of a radical, so that this substitution gives rise to a multitude of various compounds bound together by the analogy of their structure, if not by the harmony of their properties.

This last point was novel and important. Bodies belonging to one type and similar in their molecular structure may differ much in their properties: these depend not only on the arrangement of the atoms, but also on their nature. Thus the inorganic and organic bodies ranged under the type water, are, according to the nature of their elements or their radicals, powerful bases, energetic acids, or indifferent substances—a great and bold idea, which has established a connection between the most diverse bodies, and which has definitely overturned the barriers which use had raised, and which the weakness of theory had maintained, between inorganic and organic chemistry. And yet this was only a stage in the march of ideas. By what right and by what privilege, it was said, may the relatively simple compounds we have named serve as types for all others, and why should nature be restricted to make all bodies on the model of hydrochloric acid, water, and ammonia? This was a serious difficulty, but it has been removed; it became the occasion of a profound discussion and the germ of a real progress.

These typical compounds represent at bottom various forms of combination, the diversity of which it is necessary to refer to the nature of the elements themselves. The latter impress on each of these compound types a particular character and a special form. The atoms of chlorine are so formed that to one of them only a single atom of hydrogen needs to be added to form hydrochloric acid; then that an atom of oxygen takes two atoms of hydrogen to form water; that an atom of nitrogen requires three to constitute ammonium; and that an atom of carbon demands four to become marsh-gas. What a difference in the power of combination of these elements, and, so to speak, in their appetites for hydrogen! And will this difference not be connected with some peculiarities in their mode of existence, to some property inherent in matter itself, and which will impress on each of these hydrogenic compounds a special form? Such is the case.

It is now admitted that atoms are not motionless, even in bodies apparently the most fixed and in completely formed combinations. At the moment when these are being formed the atoms come into violent collision with each other. In this conflict a disengagement of heat is ordinarily observed, resulting from the expenditure of active energy which the atoms have lost in the *mêlée*, and the intensity of this heat-phenomenon gives the measure of the energy of the affinities which have presided at the combination. But there is another thing in chemical phenomena besides the intensity of the forces at work, and which are more or less exhausted by a disengagement of heat; I refer to their *mode*; it was of this elective attraction that Bergman spoke a century ago, and which governs the form of the combinations. The atoms of the various simple bodies are not endowed with the same aptitude for combination with each other; they are not equivalent to each other. This is what is called atomicity, and the fundamental property of atoms is without doubt connected with the various modes of motion by which they are animated. When these atoms combine with each other, their movements require to be reciprocally co-ordinated, and this co-ordination determines the form of the new systems of equilibrium which will be formed; that is, the new combinations.

It is with atoms thus endowed that chemists now construct molecular edifices. Resting at once upon the data of analysis and on the investigation of reactions, they express the composition of bodies by formulæ which mark the nature, the number, and the arrangement of the atoms which each molecule of these bodies contains. But what! is this merely an ingenious exercise of the mind? and the construction of formulæ by means of these symbolic materials which are selected, which are arranged so as to give to the molecular edifice a determined form,—is this a mere matter of curiosity? By no means. These formulæ, by whose aid are expressed the composition of bodies and the constitution of their molecules, offer also a valuable aid for the interpretation of their properties, for the study of their metamorphoses, for the discovery of their reciprocal relations,—all things which are intimately connected in each body with the nature and arrangement of the atoms. Now, the investigation and comparison of these formulæ furnish to the inquiring spirit the elements of a powerful synthesis. What treasures have been acquired by science by this process, which consists in deducing the transformations of bodies from their molecular structure, and in creating, by a sort of intuition, new molecules by means of those already known! The artificial formation of a number of combinations, the syntheses of as many organic compounds as nature alone seemed to have the privilege of forming—in a word, the greater part of chemical discoveries which have enriched science and the world for twenty years—are founded on this inductive method, the only efficacious and the only rational one in the sciences. I shall cite only one example among many others.

A happy chance led to the discovery of that brilliant substance, of a bright purple, which is known under the name of fuchsine or rosaniline. Analysis determines its composition, skilled investigations find its molecular structure. Soon it is known how to modify it, to multiply the number of its derivatives, to vary the sources of their production, and from attentive study of all these reactions, issue a pleiad of analogous substances whose diverse colours rival in brilliancy the richest tints of the rainbow. A new and powerful industry has already resulted from all these investigations, which theory has followed step by step and guided the fertile evolution. In this order of investigation, science has recently gained one of her most striking triumphs. She has succeeded in forming at once the colouring matter of madder (alizarin). By an ingenious combination of reactions, and by theoretic reasonings still more ingenious, MM. Graebe and Liebermann have succeeded in obtaining this body synthetically, by means of anthracene, one of the numerous bodies which is now obtained from coal-tar, the impure source of so many wonders. Such is a discovery which has issued from the womb of science, and of science the most abstract; confirming preconceived ideas on the relations of composition and of atomic structure between anthracene, alizarin, and the intermediate terms. And this will not be the last product of this beautiful development of chemistry. Future conceptions on the intimate structure of complex organic compounds will be so many landmarks for new syntheses, and hypotheses rigorously deduced from acquired principles will be fruitful in the happiest applications.

Saccharine matters, alkaloids, other complex bodies whose properties and diverse transformations are actively investigated with a view of deducing their molecular constitution—all these substances may be artificially reproduced, as soon as this preparatory work, so difficult and often seemingly so useless, will have sufficiently advanced. So fine a programme justifies the great efforts which have been made, in our days, in this direction. To discover, to analyse, to study, to classify, to reproduce artificially so many diverse substances, to study their internal structure, to indicate their useful applications; to surprise, in a word, the secrets of Nature and to imitate her, if not in her processes, at least in some of her productions such is the noble aim of contemporary science. She can only reach it by the sure but slow paths we have indicated; experiment guided by theory. In chemistry, at least, empiricism has had its day; problems, clearly stated, must be boldly faced, and henceforth the rational conquests of experiment will only leave a place more and more circumscribed for fortunate finds and the surprises of the crucible. Away, then, with the detractors of theory, who go in quest of discoveries which they can neither foresee nor prepare; they reap where they have not sown. But you, courageous workers, who trace methodically your furrows, I congratulate you. You may be sometimes deceived, but your work will be fruitful, and the goods which you amass will be the true treasure of science.

Will not this science be one day embarrassed and as if encumbered with so much riches, and will the strongest memory be able to support all the weight? If the danger exists, there is no need to fear it. The classification of all these materials will free us from embarrassment. In a well-arranged edifice, each stone requires to be prepared before taking its place; but the consruction accomplished, all do not strike the eye equally, though each has its use; only the strong courses, the corner-stones and the salient parts, are noticed. It will be thus with the monument of science. The details which have for their end to fill up gaps will disappear in the great whole, of which we only need consider the foundation, the principal lines, and the crowning of the edifice.

Gentlemen, chemistry thus constituted, and physics, have between them necessary connections. Both the one and the other investigate the properties of bodies, and it is evident that, so far as the ponderable bodies are concerned, these properties must be intimately connected with the constitution of matter. Hence the atomic hypothesis which suffices for the interpretation of chemical phenomena ought also to be adapted to physical theories. This is the case. It is in the movements of atoms and of molecules that we now seek, not only the source of the chemical forces, but the cause of the physical modifications of matter, changes of condition which it can undergo, phenomena of light, of heat, of electricity, of which it is the support.

Two French *savans*, Dulong and Petit, discovered some time ago a very simple law which connects the weights of atoms with their specific heats. It is known that the quantities of heat necessary to change by one degree the temperature of the unit of weight of bodies are very unequal. This is what we call specific heats; but the quantities of heat which bring about in simple bodies, taken under conditions in which they are rigorously comparable, the same variations of temperatures, are equal, if we apply these quantities of heat not to the unit of weight but to the atomic weight; in other words, the atoms of these elementary bodies possess the same specific heats, though their relative weights are very unequal.

But as to this heat which is thus communicated to them, and which raises their temperature equally, what is in reality its mode of action? It augments the intensity of their vibratory movements. Physicists recognise heat as a mode of motion, and that it comes under the cognisance of our perceptions by the vibrations of atomic matter or ether; of ether, that fluid material perfectly elastic, incoercible, imponderable, which fills all the immensity of space and the depth of all bodies. It is in this fluid that the stars describe their orbits; in this fluid atoms perform their movements and describe their trajectories. Thus the ether, the radiant messenger of heat and light, conveys and distributes their radiations through all the universe; and that which it loses in vibratory energy when it penetrates a cold body, which it warms, it communicates to the atoms of this body and augments the intensity of their movements; and that which it gains in energy by contact with a warm body, which it cools, it withdraws from this body and diminishes the intensity of their vibratory movements. And this kind of light and heat which come from material bodies is transmitted across space to other material bodies. You will remember in reference to this the words which Goethe put into the mouth of the Prince of Darkness in cursing the light—"It is born of bodies, it is brought forth and maintained by bodies, and it will perish with them."

But this exchange of forces which circulate from ether to atoms and from atoms to ether, must it manifest itself always in the phenomena of light or heat? This vibratory force which is transmitted by ether, can it not be preserved and stored up by matter, or appear under other forms?

It can be preserved as affinity, liberated as electricity, transformed into dynamic movements. It is this which is stored up in the innumerable compounds elaborated by the vegetable kingdom; it is this which provokes the decomposition of carbonic acid and of the vapour of water by the most delicate organs of plants which blossom in the sunlight. Originating with the sun, luminous radiation becomes affinity in the immediate organic principles which are formed and accumulated in vegetable cellules. That mode of motion of ether which was "light" is become another mode of motion which is "affinity," and sways the atoms of an organic compound. In its turn this force thus stored up is expended again when the organic compounds are destroyed in the phenomena of combustion. Affinity, satisfied and as it were lost by the combination of combustible elements with oxygen, again becomes heat or electricity. Wood in burning, and carbon in becoming oxidised, produce sparks or flames: a metal which exhausts its affinities in decomposing an acid warms the liquid, or, under other conditions, produces an electric current, warming it less when the current is exterior. And in another order of phenomena, heat which distributes or propagates itself unequally between two surfaces, rubbing one against the other, or in a crystal that is warmed, or in two metals united by solder, disappears partially as such and manifests itself as static electricity or as an electric current. Thus all these forces are equivalent to one another and appear under diverse forms, whether they are passing from atoms to ether or from ether to atoms; but we never see them disappear or lose their force—only transform themselves and perpetually renew their youth.

And this is not all. These vibratory movements which sway atoms and which whirl about in ether can cause movements of the mass, displacement either of the bodies or of the molecules. Warm a bar of iron, it will dilate with a force almost irresistible; a part of the heat will be employed in producing a certain pulling asunder of the molecules. Warm a gas, it will in like way dilate, and a part of the heat disappearing as such, will produce a separation very considerable in this case between the gaseous molecules; and the proof of the consumption of heat in the work of dilation is not difficult to give, for if you warm the same gas to the same degree, but prevent it from dilating, less heat need be given to it than in the former case. The difference between the two quantities of heat corresponds exactly to the mechanical work performed by the molecules in dilatation. That is one of the most simple considerations, on which is founded the principle of the mechanical equivalent of heat so often now referred to in mechanics, in physics, and in physiology.

In physics it explains the mystery of latent heat, of fusion, and of volatilisation. But how is it that heat supplied continuously to a boiling liquid to maintain ebullition does not ever raise the temperature of the liquid above a point which under similar pressure remains fixed? The reason is that this heat is continually absorbed, and disappears as such to produce the mechanical work of driving apart the molecules. And so in the phenomena of fusion, the constancy of the temperature indicates the absorption of the heat consumed in molecular work. These conceptions have modified and thrown much light on the definitions which physicists have applied to different states of matter, and it is seen that they are in harmony with chemical theories of the constitution of bodies. These are formed of molecules which represent systems of atoms animated by harmonic movements, and whose equilibrium is exactly maintained and strengthened by these movements.

Applied to molecules thus constituted, heat can produce three different effects. In the first place, an elevation of temperature by the increase of vibratory energy; in the second place, an increase of volume by the driving apart of atoms and molecules, and this augmentation becoming very considerable, a change of condition, solid becoming liquid, and liquid becoming gas; in the last, the driving apart of the molecules is become immense in relation to their dimensions. Thus acting on the atoms which compose the molecule and amplifying their trajectories, heat can disturb the equilibrium which exists in the system, causing a conflict of these atoms with those of another molecule in such a way that this disturbance or this conflict leads to fresh systems of equilibrium, that is to new molecules. There commence the phenomena of decomposition and dissociation, or, inversely, of combination, which is the mainspring of chemistry, and it is seen they are but the continuation or consequence of the physical phenomena we have just analysed, the same hypothesis, that of atoms, applied to one and the other with an equal simplicity.

I ask, will it not be easy to conceive that the physical and chemical forces which act on ponderable bodies are applied also to diffuse continuous matter in some way, and is it not natural to suppose that there are limited and definite particles which represent the points of application of all these forces? And this view ought to apply to the two sorts of matter which form the universe, ether and atomic matter, the one infinitely rarefied but homogeneous, filling all space, and in consequence enormous in its mass, both unseizable and imponderable; the other non-continuous, heterogeneous, and only occupying a very limited portion of space, although it forms all worlds.

Yes, it forms all worlds, and the elements of ours have been discovered in the sun and in the stars. Yes, the radiations given off by incandescent atomic matter which forms these stars are also, for the most part, those which are produced by the simple bodies of our planet. Marvellous conquest of physics which reveals at once to us the abundance of forces which environ the sun and the simplicity of the constitution of the universe!

A solar ray falls upon a prism and is turned aside in its path and decomposed into an infinity of different radiations. These take each a particular direction, and all range themselves in bands in juxtaposition, and spread themselves out in the spectrum if the light thus received and decomposed is thrown on to a screen. The visible part of this spectrum shines with all the colours of the rainbow; but besides this, beyond both ends of the coloured bands the radiations are not absent. The heat-rays can be made to reveal themselves beyond the red; the chemical rays, more powerful than the others to make and destroy the chemical combinations, are known beyond the violet. All the forces which manifest themselves on the surface of our globe, as heat, light, and chemical energy, are sent to us in a ray of white light.

But this brilliant spectrum is not continuous. Fraunhofer has discovered in it an infinity of black lines cutting the shining band; these are the "dark lines" of the spectrum, and Kirchhoff has found that a certain number of them occupy the same position as the "bright lines" which occur in the spectra of metallic substances when in a state of incandescence. This last physicist, generalising an observation of Foucault, has seen, further, that under given circumstances these bright lines can be obscured and "reversed," coinciding then with the dark lines of the solar spectrum.

We have been able to conclude that these have an identical origin and are due to radiations given off by metallic substances spread in vapour over the solar globe, radiations which are obscured by these same vapours in the atmosphere of the sun. Thus the star which gives us heat, light, and life, is formed of elements like those which form our globe. These elements are hydrogen and metals in a state of vapour. They are not distributed equally in the mass of the sun and in his rarefied envelopes; the hydrogen and most volatile metals are raised to a greater height on the surface of the sun than are the other metals. They are never in repose; this ocean of incandescent gas is continually agitated by tremendous tempests. The *trombes* throw themselves out in immense columns to the height of 50,000 leagues above the gaseous sphere; these are the "protuberances," and they shine with a rose light peculiar to themselves; and they are formed according to Janssen and Lockyer by hydrogen, very rarefied, and also by an unknown substance—"helium." The luminous globe itself, the photosphere, gives the spectra of our ordinary metals, except gold, silver, platinum, and mercury; the precious metals, those which have little affinity for oxygen, being wanting. But, on the contrary, in the solar spectrum there are "lines" different from those which the metals of our earth give, but which are like them. The lines of the metalloids are wanting, as are the lines which are characteristic of compound bodies. The gaseous mass has such an incandescence that no chemical combination could withstand it.

The lines of Fraunhofer are dark, only the lines of the protuberances and those seen a moment after the disappearance of the sun in an eclipse, and a moment before its reappearance, are bright, like those which characterise the spectra of incandescent metallic vapours. Here we have a curious relationship which has furnished most important and precise indications on the physical constitution of the sun.

I have spoken of the chemistry of the sun, but the spectroscope has explored all the far-off space of heaven. The light of hundreds of stars has been analysed, and nebulæ, scarcely visible, have had the quality of their radiations revealed by its aid. The light, in some cases very feeble, with which a number of stars shine, gives a spectrum with dark lines like the solar spectrum, and this fact proves to us that the constitution of these stars is like that of our sun. Aldebaran sends us records of hydrogen, magnesium, and calcium, which abound in solar light, but also those of metals which are rare or absent, as tellurium, antimony, and mercury.

Nebulæ, twenty thousand times less brilliant than a candle a a distance of 400 metres, have still given a spectrum, for their light, although feeble, is very simple in its constitution, and the spectrum which it gives consists only of two or three bright bands, one of hydrogen, the other of nitrogen. These nebulæ which give a spectrum of bright lines, are those which the most powerful telescopes cannot resolve: there is an "abyss" between them and resolvable nebulæ, which, like ordinary stars, give a spectrum with dark lines.

What an effort of the human mind! To discover the constitution of stars of which the distances even are unknown; of nebulæ which are not yet worlds; to establish a classification of all the stars, and still more to guess their ages—ah, tell me, is not this a triumph for science? Yes, we have classed them according to their ages. Stars coloured, stars yellow, stars white; the white are the hottest and the youngest; their spectrum is composed of a few lines only, and these lines are dark. Hydrogen predominates. Traces of magnesium are also met with, of iron, and perhaps of sodium, and if it is true that Sirius was a red star in the time of the ancients, it owed perhaps its tint to the greater abundance of hydrogen at that epoch. Our sun, Aldebaran, Arcturus, are among the yellow stars. In their spectra the hydrogen lines are less developed, but the metallic lines are fine and numerous. The coloured stars are not so hot, and are older. In consequence of their age they emit less vivid light. In them there is little or no hydrogen. Metallic lines abound, but one also finds channelled spaces like the lines of compounds. The temperature being lower, these latter can exist whether they consist of atoms joined to others of the same kind, or whether they contain groups of heterogeneous atoms. In referring recently to this classification of Father Secchi and the distribution of simple bodies in distant stars, Lockyer has observed that the elements the atoms of which are lightest are to be found in the hottest stars, and that the metals with high atomic weights are, on the contrary, met with in the colder stars; and he adds this—Are not the first elements the result of a decomposition brought about by the extreme temperatures to which the latter are exposed, and, taking them altogether, are they not the product of a condensation of very light atoms of an unknown primordial matter, which is perhaps ether?

Thus is brought forward afresh, from considerations taken from the constitution of the universe, this question of the unity of matter which chemistry has before raised from a consideration of the relative weight of atoms. It is not solved, and it is probable that it never will be in the sense here indicated. Everything leads to the belief in the diversity of matter, and the indestructible, irreducible nature of atoms. Does it not require, as M. Berthelot has pointed out, the same quantity of heat to put them in motion, whether they are heavy or light, and ought not the law of Petit and Dulong to prevail in its simplicity against the opposite hypothesis, however ingenious it may be?

I have endeavoured, gentlemen, to trace out for you the most recent progress accomplished in chemistry, in physics, and in physical astronomy, sciences so diverse in their object, but which have a basis in common—matter—and one supreme object—a knowledge of its constitution and of its properties and of its distribution in the universe. They teach us that the worlds which people infinite space are made like our own system, and that this great universe is all movement, co-ordinated movement. But new and marvellous fact, this harmony of the celestial spheres of which Pythagoras spoke, and which a modern poet has celebrated in immortal verse, is met with in the world of the infinitely little. There also all is co-ordinated movement, and these atoms, whose accumulation forms matter, have never any repose; a grain of dust is full of innumerable multitudes of material unities each of which is agitated by movements. All vibrates in the little world, and this universal restlessness of matter, this "atomic music," to continue the metaphor of the ancient philosopher, is like the harmony of worlds; and is it not true that the imagination is equally bewildered and the spirit equally troubled by the spectacle of the illimitable immensity of the universe and by the consideration of the millions of atoms which people a drop of water. Hear the words of Pascal: "I wish to picture not only the visible universe, but the immensity of nature that one can conceive within the limits of an atom; one may picture there an infinity of worlds, where each has its firmament, as in the visible universe."

As to matter, it is everywhere the same, and the hydrogen of water we meet with in our sun, in Sirius, and in the nebulæ everywhere it moves, everywhere it vibrates, and these movements which appear to us inseparable from atoms, are also the origin of all physical and chemical force.

Such is the order of nature, and as science penetrates it further, she brings to light both the simplicity of the means set at work and the infinite variety of the results. Thus, through the corner of the veil we have been permitted to raise, she enables us to see both the harmony and the profundity of the plan of the universe. Then we enter on another domain which the human spirit will be always impelled to enter and explore. It is thus, and you cannot change it. It is in vain that science has revealed to it the structure of the world and the order of all the phenomena; it wishes to mount higher, and in the conviction that things have not in themselves their own *raison d'être*, their support and their origin, it is led to subject them to a first cause—unique, universal God.

SCIENTIFIC SERIALS

THE *Mittheilungen aus dem Göttingen Anthropologischen Vereine*, which are edited by Dr. Hermann von Jhering, promise to give important contributions to the department of anthropological science, and the appearance of these selections from the Transactions of the Society will be hailed with satisfaction. The first number contains an interesting paper on the origin of our knowledge of iron and bronze in Europe, by Prof. F. W. Unger, in which the author considers *seriatim* (1) the application of bronze for religious or sacrificial objects; (2) the linguistic affinity of the terms for ores, or metal generally, in different languages; (3-6) the mythical references to their use, seat of original works and the modes of employing bronze for and in connection with ceremonies of cremation. The section under which Prof. Unger treats of the myths and sagas connected with the history of the discovery and the first working of metals is especially interesting in regard to the early knowledge of iron possessed by the Tschudi, or primitive people of the Altai, through whom he believes that the Indo-Germanic races derived their acquaintance with its sources and modes of working.—A paper on skulls of extreme breadth, by Dr. von Jhering, which is rather a compendium of what has been done towards the definition of normal and abnormal types than a contribution of original matter, is aptly supplemented by the description of a new craniometer, given in the concluding extracts of the Transactions by Dr. W. Sprengel, who draws attention to the important direction taken by craniometrical inquiries in the course of the last year by the introduction of Dr. von Jhering's horizontal-plane apparatus, of which plates and detailed explanations are appended by the writer.—In a paper on the very widely-spread custom of tattooing the human body, in which some inquirers have believed they could trace the earliest origin of the art of using graved and written characters to express ideas, Herr Krause considers whether in this far-extending practice we have not an argument in favour of the unity of the human race. The author is not of opinion that we are justified in accepting this suggestion as capable of proof, but he thinks that this practice, against which Moses warned the Israelites, had a far higher significance than that of mere personal ornamentation, and was probably at one time or other associated with the religion of the several peoples who adopted it, while it also served as an emblematic emblasonment of the pretensions or calling of the wearer, a talismanic or hieroglyphic form of speech, and as a permanent pictorial exponent of facts in the absence of any other written language.

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