THURSDAY, OCTOBER 17, 1889.

THE ELEMENTARY TEACHING OF SCIENCE.

PERHAPS the most important event in the Chemical Section at Newcastle was the presentation of a second Report (the first part of which we print elsewhere) by the Committee[1] appointed "to inquire into and report upon the present methods of teaching chemistry." It is a remarkable fact that the daily Press in general has made only the barest possible reference to the Report or to the animated discussion which followed its reading; although, as the *Times* points out, "there is a Committee attached to Section B, the professed purpose of which is to inquire into and report upon the teaching of chemistry; the truth is, however, that it involves the wide question of science teaching in general. The national importance of such an inquiry is evident, and it behoves all the Sections to take an interest in it."

At the Bath meeting the Committee reported on the condition of chemical teaching in the principal public schools of Great Britain and Ireland, their Report being founded upon information obtained from the principals, head masters, and science masters of these schools. This Report demonstrated the existence of a most unsatisfactory state of things. It proved unquestionably that physical science still occupies a very subordinate position in most of our public schools, and it appears that this is the result, in no small measure, of the manner in which it is taught. The attempt to cram the minds of boys with a conglomeration of chemical facts under the name of "science" has reached a crisis; and head masters, and even some parents, are beginning to feel, and to say in so many words, that science teaching, which has been on its trial for so many years, has failed to produce the educational effect which was expected from it. The teachers, while complaining of the various difficulties which surround their attempts to teach chemistry, *e.g.* insufficient time and laboratory accommodation, frankly admit that the methods at present employed in teaching the science are for the most part ineffective, and that to this circumstance may be attributed, in the majority of instances, the inferior position which is assigned to the subject in the school curriculum. Partly in self-justification, and partly as an explanation of the continued existence of these abortive methods, teachers have drawn attention to the requirements of the various examining bodies by which their hands are tied. It is rare to find the science master who is free to break away from conventional lines, and to use chemistry in illustration of the scientific method of questioning Nature, instead of relating to his boys the properties of all the elements from hydrogen to uranium, and by a system of laboratory drill instructing them how to "test" rare compounds or absurdly complex mixtures. Of the few examinational schedules which are likely to assist the teacher in making his elementary instruction in science most useful as an educational instrument, special mention may here be made of the syllabus of physiography issued by the Science and Art Department, having been drawn up by Mr. Norman Lockyer, and of the syllabus issued by the same Department for the "Alternative First Stage in Chemistry" (why should not this be made *the* "First Stage in Chemistry"?), which was compiled by two members of the present Committee, Sir Henry Roscoe and Dr. Russell.

The Committee thought that they might be able to do something towards a reorganization of elementary instruction in science; in fact several teachers had pointed out that the Committee were most favourably constituted for taking such action, and that they would doubtless be able to induce examining Boards to reconsider their present regulations.

About the middle of the present century two schools of educational authorities were actively engaged in propagating their views. The one school contended that the object of primary education should be to teach those subjects which can be practically applied in after life, while the other asserted that its main object should be to develop the faculties and not merely to store the mind with knowledge. Chemistry, no doubt, was introduced into the school curriculum chiefly to satisfy the demands of the first theory, but nevertheless it may equally well serve the purposes of the second. The mental discipline afforded by chemical investigation in developing the powers of observation and inference, and in teaching the correct use of hypothesis, is not less conspicuous than the many applications of which the science is susceptible both in industrial and "common" life. Happily, of late years, a fusion of these two theories has taken place, and agreement has very generally been reached on two important points. First, that the main purpose of elementary education should be to train the intelligence. In this sense "education is a high word—it is nothing less than the formation of mind." Secondly, it is admitted that before a man can apply science to practice he must be familiar with its methods, his mind must be able habitually to perform those logical processes which accurate thought demands. We are now fairly unanimous in the opinion that it should be the endeavour of elementary education to develop habits of correct observation and reasoning, so that in later life the more advanced knowledge of science, which will subsequently have been acquired, may be intelligently applied to the solution of social and industrial problems.

In the opinion of the Committee, this training of the intelligence can be readily effected by a properly arranged course of elementary instruction in physical science. This fact is, however, not recognized by the majority of educational authorities, since chemical teaching, which represents physical science in most schools, has hitherto been chiefly directed to the acquisition of a vast number of chemical facts. But the "learning of true propositions, dogmatically delivered, is not science," and does not produce any mental effect that cannot as well be reached by many other paths, *e.g.* the multiplication table and the facts of English history. So far, the public in this country have had very few opportunities of judging of the educational value of physical science, and it is to be feared that they have not yet sufficiently recognized the truth and significance of Herbert Spencer's definition of

[1] Consisting of Prof. H. E. Armstrong, F.R.S., Prof. W. R. Dunstan (Secretary), Dr. J. H. Gladstone, F.R.S., Mr. A. G. Vernon Harcourt, F.R.S., Prof. McLeod, F.R.S., Prof. Meldola, F.R.S., Mr. M. M. Pattison Muir, Sir Henry E. Roscoe, F.R.S., Dr. W. J. Russell, F.R.S. (Chairman), Mr. W. A. Shenstone, Prof. Smithells, and Mr. G. Stallard.

science as "trained and organized common-sense," which implies that those same mental processes whose use has led to great scientific discoveries are also applicable to even the commonest affairs of life with equally successful results. In order to make chemistry subservient to the needs of mental education, it is necessary to depart almost entirely from the usual method of teaching it, which is better adapted for the subsequent training of those comparatively few students who intend to follow chemistry as a profession. Instead of attempting to traverse the greater part of the science, the teaching must be restricted to those portions of it which best exemplify the scientific method of investigation; and it should, as far as possible, have reference to objects which are more or less familiar to the pupils, or which can be readily understood by them.

The Committee having agreed as to the principles on which a scheme of elementary instruction should depend, Prof. Armstrong undertook to prepare a series of suggestions for an actual course of instruction in sufficient detail to serve as a general guide to teachers. These suggestions form a part of the Committee's Report, and are of very considerable importance. The course is divided into six "stages." Stage I. deals with lessons on common and familiar objects; the classification of these according to their uses and origin; elementary physiography and *Naturkunde*. Stage II., with lessons in measurement. Stage III., with studies of heat on things in general; of their behaviour when burnt. Stage IV., the problem stage—to determine what happens when iron rusts; to determine the nature of the changes which take place when substances are burnt in air; to separate the active from the inactive constituent of air; to determine the composition of chalk; to determine what happens when organic substances are burnt; to determine what happens when sulphur is burnt; to determine what happens when metals are heated with acids; to determine what happens when oxides are treated with acids; to determine what happens when the gas obtained by dissolving iron and zinc in sulphuric acid or muriatic acid is burnt; to determine what happens when hydrogen and other combustible substances are heated with oxides; to determine whether oxides, such as water and chalk gas, may be deprived of oxygen by means of metals; to determine the composition of salt-gas and the manner in which it acts on metals and oxides; to determine the composition of washing-soda. Stage V., the quantitative stage: study of the quantitative composition of some of the substances which have already been qualitatively examined. Stage VI., studies of the physical properties of gases in comparison with those of liquids and solids; the molecular and atomic theories, and their application.

Without pledging themselves to accept every detail, many of which would naturally be modified by teachers to suit their own special cirumstances, the Committee state that Prof. Armstrong's suggestions are typical of the kind of instruction which they wish to see generally introduced into schools. They prefer to speak of it as a course of elementary instruction in "physical science," since, although it is mainly chemical, physical problems are largely introduced, and the course, as a whole, may be looked upon as a suitable introduction to the study of any of the physical sciences.

In bringing this scheme under the notice of teachers, the Committee make several recommendations as to the manner in which it should be carried out, but these can only be briefly alluded to here. They insist that the instruction should be commenced with young children, and that every pupil in the school should receive it. In order that it may be successful, a fair share of the school time must be devoted to the subject, and a larger number of teachers must be employed than is now usually the case. While this may lead to some extra expense, on the other hand it is pointed out that the simplest laboratory fittings and apparatus are all that will actually be needed. Thus the expenditure attending the adoption of the new course need not be greater than it is now in those schools where science teaching occupies a prominent place among the subjects of study.

Space does not allow of more than a passing mention of the series of statistics in reference to the teaching of chemistry in public elementary schools which have been admirably collected and commented upon by Prof. Smithells, and which form the second part of the Report. As in the higher public schools, the teaching of elementary science in these institutions is shown to be far from satisfactory, and here also a scheme of the kind suggested by the Committee might be introduced with very great advantage.

In the discussion which followed the reading of the Report the Committee had the satisfaction of learning that their recommendations receive the approval of several teachers of experience. A representative of Section E stated that those interested in the efficient teaching of geography felt strongly that the course of work advocated by the Committee was on the proper lines. The head master of a large elementary school complained of the present methods of teaching chemistry, and stated that they tended so strongly towards making those who followed them into professional and technical chemists, that he had been obliged to substitute for chemistry instruction in some other branch of science. A useful contribution to the discussion was made by a former assistant science master in one of the largest public schools in London, who gave a graphic account of the hardships which were suffered by the solitary science master and his assistant in their efforts to teach "practical chemistry" to large classes of boys. If the comparison he instituted between the methods respectively adopted in this school in teaching classics and science be true, and if his statistics are correct as to the number of boys who are "taught" science, and the number of masters employed to teach them, they reveal a scandalous state of affairs, which no City Company ought to tolerate in a school which it endows. Finally, Prof. Armstrong read letters which he had received from Prof. Huxley, the head master of Rugby, Sir Philip Magnus, and other authorities, in which they spoke with approval of the scheme for science teaching which the Committee advocate in their Report.

It seems likely, then, that through the action of this Committee a considerable impetus in a new direction will be given to the elementary teaching of science in this country. The words which Mark Pattison wrote more than twenty years ago are as true now as they were then, and may appropriately bring these remarks to a conclusion. "The dispute between science *versus* classics in education will not be settled on paper or by discussion. It will be settled, in fact, by the establishment somewhere or other, and in some form or other, of a system of scientific education, the results of which will vindicate themselves. We may argue, and vested interests may resist, but the tendency of things is unmistakable—the sciences will end by conquering their place."

W. R. D.

CORRESPONDENCE OF CHRISTIAN HUYGENS.

Œuvres Complètes de Christiaan Huygens. Publiées par la Société Hollandaise des Sciences. Tome Deuxième : Correspondance, 1657–59. (La Haye : Martinus Nijhoff, 1889.)

THE second volume of the great edition of Huygens's works, the first volume of which was noticed last year in these pages (NATURE, vol. xxxviii. p. 193), has made its appearance with creditable promptitude. The letters included in it range from 1657 to 1659. That they are numerous and elaborate is sufficiently shown by the bulk of their receptacle ; their value might be taken on trust from the names of the writers, and can be ascertained by the somewhat laborious process of perusal. This, however, may be curtailed at pleasure by having recourse to a series of admirably-constructed indexes, aided by which, readers, exempted from the ignominious necessity for "skipping," are enabled to find what they want, and neglect what less immediately concerns them.

Scientific correspondence was in those days of far greater importance than it is now. It, in fact, to a great extent, took the place of scientific journalism. There was then no recognized channel of public criticism. The first numbers of the *Philosophical Transactions* and the *Journal des Savans* appeared within a few months of each other in 1665 ; the *Acta Eruditorum* began to be published at Leipzig only in 1682. The learned formed a cosmopolitan caste, using a cosmopolitan language. They made an audience "fit and few" for each other's communications, and cared little, in general, to address a wider public. Epistolary intercourse assumed, accordingly, proportions and a significance which we find it difficult to realize. From one end of the Continent to the other, workers were, by means of letters nominally private, kept *au courant* of the progress of invention, readers of the course of publication ; ideas and criticisms were interchanged ; authors were informed of the impression produced by their works ; controversies were conducted or commented upon.

In the correspondence now before us, indeed, there is small trace of the *odium scientificum.* Although often obliged to stand on the defensive against unjust attacks upon his originality, Huygens never lost self-control. The *scelerata insania belli* had no place in his calm and reasonable mind. His reticence is strikingly illustrated by the incident of the feigned anagram, left unfinished and mysterious by the earlier letters, but brought to a satisfactory conclusion in the present collection. The bogus claim put forward by Dr. Wallis to the detection of Saturn's first-known satellite, proves, in accordance with the conjecture emitted by Mr. Maunder in the *Observatory* for last March, to have been an infelicitous practical joke. It enforced, however, a designed moral by rendering palpable the protective inefficacy of crytographical announcements ; and no more was heard (that we are aware) of the entrenchment of discoveries or inventions behind logogryphs. Huygens continued in a state of mystification on the point for above three years, the Savilian Professor's first explanatory letter having miscarried ; but he allowed his natural irritation only the vent of a few jottings of a strictly private character.

The publication of Huygens's "Systema Saturnium" was the leading event of the period now under consideration. The book was long and eagerly expected, and was received—so far as letters acknowledging the receipt of "complimentary copies" enable us to judge—with a chorus of approbation. Its author, at the age of thirty—Galileo being already dead, and Newton as yet unknown—found himself pre-eminent among the astronomers of Europe. "*Ora ha Giotto il grido.*" Yet the flattering assurances with which he was overwhelmed did not wholly exclude some expressions of misgiving. The physical and mechanical difficulties attending the existence of such a Saturnian system as he described were very great. The hypothesis of a ring was no doubt beautifully ingenious, and accounted for observed phenomena with the utmost neatness and sufficiency ; but was it true ? Was such an incredible structure, in point of actual and undeniable fact, to be found in the heavens ? Such questionings could not but arise, and were only finally set at rest by the predicted complete disappearance of the anomalous appendages as the earth got to the unilluminated side of them towards the end of 1671.

Saturn's ring-system has now so long held a place in astronomical consciousness that it costs an effort of the imagination to conceive the audacity of the first attempt to establish it there. Its author himself did not look for immediate and unqualified assent. All he hoped for was that his mode of accounting for the "bizarre appearances" of the "triple planet" should get an unprejudiced trial. Writing to Slusius in September 1659, he congratulated himself that his hypothesis had not struck him as absurd ; and he met the scruples of objectors with a quiet appeal to time. It has not failed to justify his confidence.

An incidental paragraph in the "Systema Saturnium" (p. 9), announcing the virtual discovery of the great Orion nebula, appears to have excited little attention. Huygens's correspondents passed it over in silence ; he took no trouble to invite their opinions on the subject ; nor is there evidence that any of his subsequent observations were directed towards that "gap" (as it were) in the crystalline vault through which the glimmering of empyreal fire was discernible. Still more singularly, Hevelius, although he catalogued the stars, and enumerated fourteen nebulæ, did not include among them the Orion "portent," upon which, indeed, he seems never to have had the curiosity to direct his telescope (H. Schultz, *Astr. Nach.*, No. 1585). The first intelligent observer of nebulæ was Halley.

A sidereal phenomenon of another sort, however, attracted considerable attention in the learned *côteries* of Paris and the Hague. Janson's "new star," *in collo Cygni*, was again visible in 1658–59 First seen in 1600 as of the third magnitude, it disappeared from view in 1621, but was re-detected, in its pristine brightness, by Domenico Cassini at Bologna in 1655. The news seems to have taken no less than three years to filter to the Low Countries. Golius, of Leyden, was one of the first to get hold of it, and he transmitted it to Boulliau, of Paris, who thereupon perceived, plainly enough, a brilliant star shining in the place of a usually telescopic one. As an example of mental inertia comparable to that afforded by Hevelius with regard to the Orion nebula, it is worth noting that the object had caught his eye twelve days previously, but without rousing his attention. He imparted to Huygens his conviction that the Milky Way "provided the material for such generations," among which he included comets; and judiciously wound up his speculations by urging the necessity for continued observation.

His correspondent had anticipated the recommendation. His interest in the "renaissante of the Swan" (as he termed it) is shown by various remarks; but a more formal essay on the subject, alluded to in a letter to the Sicilian astronomer Hodierna, has not been preserved. Huygens considered the star, on November 20, 1659, to have lost none of its lately-acquired brilliancy. Boulliau, however, had already noticed a diminution in *size*, though not in *lustre* (a distinction to which he evidently attached some importance), and on December 12 saw further symptoms of fading in its pale and languid aspect. From the decline which then set in, it has never completely recovered, but has remained, since the abortive maximum of 1665, undistinguished by conspicuous vicissitudes. "P Cygni," as Janson's star is called in modern nomenclature, now betrays peculiarity of constitution only by the bright hydrogen lines photographically discovered by Prof. Pickering in its spectrum.

Huygens's invention of the pendulum clock is a prominent topic in the correspondence before us. He was not without hope of solving, by its means, the ever-recurring problem of longitudes, "if only it would bear transport by sea"—a prudent qualification. Of curves and quadratures, telescopes and lenses, chronometry, meteorology, mechanics, the theory of numbers, much is said, showing the working of thought along these various lines of research. There is scarcely, in fact, a branch of scientific history which is not usefully illustrated by these valuable letters.

A. M. CLERKE.

THE ANATOMY OF THE HUMPBACK WHALE.

The Anatomy of the Humpback Whale (Megaptera longimana). By John Struthers, M.D. (Edinburgh: 1889.)

THERE is probably no order of Mammals which during the last twenty-five years has been more worked at than the Cetacea. The result has been that we now possess a valuable body of information on both the classification and anatomy of this most interesting group of animals. On the continent of Europe, the names of Eschricht, Reinhardt, Lilljeborg, Van Beneden, and Gervais stand out most prominently as authorities; whilst in this country Sir Richard Owen, Profs. Flower, Struthers, and Turner, Dr. Murie, and Prof. Macalister, have all written valuable memoirs which have added largely to our knowledge of the whales. Through the combined labours of these anatomists the order has been rescued from the state of confusion into which it had been thrown by some systematic writers, who, by regarding almost every specimen stranded on our coasts as a new species, had introduced a complexity of nomenclature which was most puzzling.

The humpbacked whale, the anatomy of which forms the subject of Prof. Struthers's memoir, is, from its form and structure, one of the most interesting of the occasional visitors to our coasts. The number of specimens the capture of which has been recorded in British waters, prior to that of the specimen dissected by Dr. Struthers, was only three: viz. a female cast ashore near Newcastle in September 1829, and described by the late Dr. George Johnston; another female taken in 1863 in the estuary of the Dee, the skeleton of which is in the Derby Museum, Liverpool; and an adult towed into Wick Bay in March 1871, the skeleton of which was not preserved. This whale is, however, not uncommon in the North Atlantic, more especially off the coasts of Norway and Finmark, and in the seas of Iceland and Spitzbergen.

The specimen described in Prof. Struthers's memoir was seen in the Firth of Tay, in the month of December 1883. It was harpooned, but broke away from its captors, was ultimately found floating dead off Bervie, and was towed into Stonehaven Harbour on January 8, 1884. It is fortunate that it fell into the hands of so competent an anatomist and so enthusiastic a cetologist as the Aberdeen Professor. Thanks to his untiring energy and industry, he has furnished us with a monograph on the external characters, the skeletal anatomy, the muscular anatomy of the pectoral limbs, and the connections of the pelvic bones and rudimentary hind limbs of this animal, far more precise and detailed than had been given by any previous anatomist. He has added also greatly to the value of his description by instituting a comparison between the skeleton of Megaptera and that of *Balænoptera musculus*. The memoir will have to be studied by all cetologists who wish to have an exact knowledge of the anatomy of this great baleen whale.

OUR BOOK SHELF.

First Mathematical Course. Blackie's "Science Text-Books." (London: Blackie and Son, 1889.)

THIS little work, comprising arithmetic, algebra (as far as simple equations), and the first book of Euclid, is adapted to the requirements of the examinations of the Science and Art Department in mathematics (Subject V.), first stage. The more elementary parts of arithmetic have been briefly treated, as the pupil will have most probably reached fractions, but great attention has been paid to the examples, which are both numerous and judiciously chosen. The algebraical part is completed up to and includes simultaneous equations, and here, as in the arithmetical part, we have a great number of well-arranged examples, including those set for this stage in previous examinations. Part III. consists of the first book of Euclid with exercises on the various propositions. Preceding the answers to the examples is an appendix containing specimen examination papers set by the above-named Department. Teachers, who require a great number of easy examples on these three branches of mathematics, will find this book very useful.

Key to Todhunter's Integral Calculus. By H. St. J. Hunter, M.A. (London: Macmillan and Co., 1889.)

ALL the examples in Todhunter's "Integral Calculus" are fully worked out in this volume. In the earlier chapters, the solutions are exhibited with considerable detail, so that the "Key" will be a valuable aid to those who are beginning the subject without the help of a teacher. Throughout the work many references are made to the text, the edition referred to being that of 1886.

The Hand-book of Jamaica for 1889-90. By A. C. Sinclair. (London: Edward Stanford. Jamaica: Government Printing Establishment.)

THIS is the ninth annual issue of Mr. Sinclair's "Hand-book," and to those who have already had occasion to consult the work we need hardly say that it contains all the information, clearly and compactly presented, that is likely to be wanted by its readers. The writer provides a good description and historical sketch of Jamaica, and full details are given with regard to all the leading institutions of the island. The volume is published by authority, and has been compiled from official and other trustworthy records.

LETTERS TO THE EDITOR.

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

The Method of Quarter-Squares.

MAY I point out, by way of note to Mr. Glaisher's article (October 10, p. 573) on the method of quarter-squares, that the method is indicated in the second edition of Sir John Leslie's "Philosophy of Arithmetic" (Edinburgh, 1820; see pp. 246-57). Leslie gives what he calls a "specimen" table, extending as far as 2000, whereby any two numbers containing not more than three digits each can be multiplied; and he also points out the application of the table for any two numbers less than 2000 by using the formula—

$$ab = 2\left\{\frac{a^2}{4} + \frac{b^2}{4} - \frac{(a-b)^2}{4}\right\}.$$

Apparently, Leslie was an independent discoverer of the method; at least this seems to be implied in the remarks which follow his table in the work cited above:—"This application of a table of quarter-squares, as it is derived from the simplest principles, might have readily occurred to a mathematician; yet I have nowhere seen it brought into practical use till, last summer, I met with, at Paris, a small book by Antoine Voisin, printed in 1817. It contains a table of quarter squares for the multiplication of whole numbers from 1 to 20,000, with an explanation of the mode of employing them." G. CAREY FOSTER.

University College, London, October 13.

Marine Biological Association.

THE British Association, at the recent meeting at Newcastle placed a grant of money in the hands of a Committee, consisting of Prof. W. H. Flower, Prof. M. Foster, Prof. E. Ray Lankester, Prof. S. H. Vines, and myself (Secretary), "for the purpose of nominating students to work at the Laboratory of the Marine Biological Association at Plymouth." Arrangements are being made with the Council of the Marine Biological Association, by which the Committee hope to obtain the use of a table at the Laboratory at Plymouth for twelve months.

May I ask you to assist, through the medium of NATURE, in making this information public? Persons who wish to take advantage of the opportunity, afforded by the British Association, of working at the Plymouth Laboratory should address their applications to me at the earliest possible date. The application should contain full particulars as to the nature of the investigation which it is proposed to carry on, together with a statement of the period of time during which the applicant would be able to work at Plymouth. S. F. HARMER.

King's College, Cambridge, October 15.

Section Work at the British Association.

THE recent meeting at Newcastle has emphasized what has been frequently noticed before, that the British Association week undoes the benefit of previous holiday, and that the conditions under which the work of the Sections is carried on are prejudicial to health, and have this time resulted in a considerable list of sick and wounded. I speak especially of Section A, but have no reason to suppose it different from others.

The principal difficulty is the elementary one of food. A satisfactory midday meal is at present practically unattainable, unless one is willing to sacrifice everything else to it. The time of meeting (from 11 to 3, or, for those more intimately connected with the business of the Sections, from 10 to 5) and the practice of non-adjournment for lunch are to blame for this; and I write to raise the question, whether it may not be wise to reconsider the time-honoured meeting-hours both of Sections and of Committees. Several proposals can be made, but the one I wish to bring forward is, to postpone the Sectional Committee meetings till after the Section has sat, and to begin the Section work at 10 a.m. The work should begin then more freshly than it does now after an occasionally tedious, though occasionally interesting, Committee meeting; and it may go on steadily till 1.30, when it will usually stop for the day. At 2.30, or possibly, but less advantageously, at 2, the Sectional Committees can meet and transact their business comfortably. It will be easier to arrange the papers for next day when it is known how many stand over from the recent meeting; and as the Secretaries usually have things pretty well arranged beforehand, there need be no difficulty or delay in getting the list to the printer in good time. The important business of appointing Committees and such-like can be discussed very rationally after the Committee or individual has just reported to the Section, instead of, as at present, before such report. At 3.30 the General Committee and the Committee of Recommendations can meet, instead of at 3. This apparent lengthening of the day's work by half an hour will be more than compensated by a comfortable sit-down lunch, and one useful function of the Association, viz. the interchange of ideas in conversation, will be much assisted. It may be objected that, if all the Sections rise at 1.30, the luncheon-room will be inconveniently crowded, but there are usually many clubs and private houses available; and if a midday meal became a feature, there is no lack of hospitality. The usual difficulty is how to fit anything social into the crowd of engagements and evening lectures.

My proposal curtails the Section time by half an hour. Whether this is regrettable or not, I am not sure: there are ways of avoiding it if it is. If any hard-pressed Section chooses, it might meet again at 3.30 on every day but Monday, and sit, concurrently with the Committee of Recommendations, for an hour or two without essential hardship. What I feel sure ought to be reconsidered, is the present health-destroying practice of continuous session. OLIVER J. LODGE.

Anthropometric Measurements at Cambridge.

I QUITE agree with your correspondent "F. M. T." that the head measurements are not sufficiently accurate to warrant their use as data for coming to any conclusion as to increased cranial capacity, much less as the foundation for the theories of Mr. Francis Galton. On a comparison of the head measurements of any one individual, they are found to be so variant that one is forced to conclude that the errors of observation are far greater than the maximum error which could exist without completely vitiating the trustworthiness of the data. The following measurements of my head during the last two years are sufficient to render this obvious—

	Breadth.	Length.	Above line from brow to ear-lobe.	Total.
May 28, 1887	5·7	7·4	5·3	223·55
November 19, 1887	5·6	7·3	5·5	224·84
June 14, 1888	5·8	7·4	5·5	236·c6
February 4, 1889	5·7	7·3	5·2	216·37
August 23, 1889	5·8	7·5	5·4	234·90
August 30, 1889	5·8	7·4	5·6	240·35

I would particularly call attention to the third and fourth measurements, as also to the last two, and venture to think that no one could entertain the trustworthiness of data that involve such great changes in cranial capacity in such short spaces of time. To what, then, are these differences due? Partly, of course, to unavoidable errors of observation. This, however, I think is only a small portion of the differences. The main difference is, I believe, due to other causes. Anyone who has seen the instruments will recognize that they are far too rough and imperfect to measure small differences with any degree of accuracy, and yet it is on differences as small as one-tenth of an inch that Mr. Galton's calculations are based.

I admit it is quite possible that, even after elimination of the errors due to experimental causes and to the imperfection of the instrument, the figures would still be somewhat variable. These variations may, however, be readily explained, without the assumption of any improbable head-growth. The amount of hair on the head must considerably influence the measurements, and, according as it is long or short at the time of measurement, so will the figures show an increase or a decrease. I have tested this, and proved it to be the case. On August 30 (my hair not being very long, having been cut two and a half weeks previously) my head was measured, the figures being as follows:—

$$5{\cdot}8,\ 7{\cdot}4,\ 5{\cdot}6 = 240{\cdot}35.$$

I then had my hair cut fairly short, and was measured again; the figures then read—

$$5{\cdot}7,\ 7{\cdot}4,\ 5{\cdot}5 = 231{\cdot}99.$$

Again, the scalp being, as is well known, very vascular, any change in the fulness of its vessels must materially affect the thickness of the scalp, and so influence the measurements, and so any cause producing either increased blood-flow or hindering the return of blood from the scalp, will have some effect on the measurements.

Several other similar explanations of supposed head-growth might be given, but I think the measurements I have given will suffice to show the uselessness of the measurements for calculating head-growth, and, further, that such differences as actually do exist can be readily explained without having recourse to any such improbable assumption as the further growth of the head after nineteen years of age, and without involving the unintelligible statement that the head of a "poll" man grows more than the head of an honour man. This would necessitate the supposition that a "poll" man, by his three years' study (?) at Cambridge, profits more than an honour man! Such an hypothesis would need more scientific proof than has been given.

Trinity College, Cambridge, September 3. H. J. P.

Glories.

COLOURED rings are often seen surrounding the shadow of the spectator's head when the sun is shining on a fog of water particles. They are known by various names, such as glories, anthelia, Ulloa's rings, &c. Can any of your readers inform me if they can also be seen when the fog is frozen? I should also be glad of accurate accounts of their colour and angular dimensions. I have read those given by Scoresby (Kaemtz, "Meteorology," translated by Walker); Flammarion (Glaisher's "Travels in the Air"); Abercromby (*Phil. Mag.*, January 1887); and Mohn (NATURE, February 1888).

JAMES C. MCCONNEL.

Hotel Buol, Davos, Switzerland.

Fine Slow-moving Meteor.

ON September 25, at 8h. 5m., I saw a bright first-magnitude meteor amongst the stars of Aquarius. It moved very slowly to the east, and, after a duration of about 13 seconds, disappeared at the point R.A. 11°, Decl. + 8°. Its place of first appearance was near R.A. 332°, Decl. − 7½°, so that the length of its observed path was about 42°. The nucleus was followed by a thick train of sparks, and at the end it divided into two parts. This meteor was observed at Oxford by Mr. W. H. Robinson, of the Radcliffe Observatory. He writes:—"This evening a fine meteor was seen slowly moving between the constellations Aquarius and Pegasus, at 8h. 5½m. G.M.T. It was first seen at R.A. 330°, N.P.D. 88°, disappearing near R.A. 352°, N.P.D. 82°; duration, 3 or 4 seconds." A comparison of these observations shows that the radiant point was probably in R.A. 244°, Decl. − 22°, and that the meteor, when first seen, was at a height of 46 miles over a point in the English Channel 20 miles south of the Isle of Wight. It disappeared near Staplehurst, in Kent, at the same height. Length of path, 100 miles. At Oxford, the early part of the meteor's flight was not seen. The Bristol observer watched the meteor through 91 miles of its course, and the duration of 13 seconds would give a velocity of 7 miles per second. At Oxford, 35 miles of the terminal section of the flight was seen in 3 or 4 seconds, which gives a velocity of 10 miles per second.

Further observations of this body would be valuable to corroborate these results. The meteor was an exceptional one, both as regards its slow speed and the position of its radiant point. No meteor-shower has hitherto been recognized at this epoch in the region of Scorpio. Isolated slow-moving meteors of this description are of great value as giving us indications of feeble systems not otherwise discoverable, and as allowing good determinations to be made of their heights and velocities.

Bristol, October 4. W. F. DENNING.

A Brilliant Meteor.

AT 7h. 6m. ± p.m. G.M.T., on October 10, a brilliant meteor was observed here, about 10° south-west of α Pegasi, and travelling from thence to near Jupiter, being apparently three times the size and brilliancy of that planet. Its colour was of a bluish-white, and it possessed a fine train, disappearing after six seconds, having burst into a number of pieces. W. HUGO.

Kew Observatory, Richmond.

The Shining Night-Clouds—An Appeal for Observations.

THE following is the substance of an appeal for observations made by Herr O. Jesse in the spring. The time of year in which the clouds appear in these latitudes has now elapsed; I have seen no sign of them this summer, either in this country or while travelling in the Alps. But as Mr. D. J. Rowan saw them (see NATURE, June 13, p. 151) it is very desirable that they should be looked for in all parts of the world. I see Mr. Le Conte assumes (October 3, p. 544) that Mr. Rowan is correct in calling these clouds self-luminous—which conclusion I agree with Herr Jesse in considering highly improbable.

Sunderland, October 12. T. W. BACKHOUSE.

The time of year has again arrived when the lustrous silvery clouds, which have appeared annually in June and July from 1885 to 1888, may be expected to again become visible to observers throughout Europe.

These clouds are not only of high meteorological interest, but may be of an almost greater astronomical one, for, from their so decidedly pronounced periodicity, joined to their extraordinary height, it may perhaps be inferred that they are of extra-terrestrial origin.

As there is entire lack of previous record of these clouds, and they may disappear soon for an indefinite period, I would earnestly ask for such early observations as may be likely to determine their origin, nature, and periodic motion. Spectroscopic examination of their light would be valuable. Prof. Galle and others have considered that the clouds in question are phosphorescent, but this is very improbable, and I hold they are scarcely, if at all, visible unless the sun shines directly upon their substance. On this assumption, their height in 1885 was found to be from 49 to 54 kilometres; but, by photographic observations in 1888, it came out as great as 75 kilometres.

Prof. Kohlrausch advances the opinion that these clouds have in some way been formed by the eruption of Krakatão, although they were not generally seen until nearly two years after that event. From this hypothesis I suggest that they may be caused by the condensation of gases from that volcano, and that the process of condensation occupied the intervening time. One observer, however, states that he saw them in 1884.

NOTES.

WE deeply regret to have to record the death of James Prescott Joule, one of the greatest men of the age. He died on Friday last at his residence at Sale, near Manchester.

PROF. H. G. SEELEY, who has recently returned from an expedition to South Africa, has obtained from the Karroo, among a large number of other treasures, a complete specimen of the much-discussed *Parieasaurus*.

THE ordinary general meeting of the Institution of Mechanical Engineers will be held on Wednesday, October 30, and Thursday, October 31, at 25 Great George Street, Wesminster. The chair will be taken at half-past seven p.m., on each evening, by the President, Mr. Charles Cochrane. The following papers will be read and discussed, as far as time permits:—On the results of blast-furnace practice with lime instead of limestone as flux, by the President; description of a rotary machine for making block-bottomed paper bags, by Mr. Job Duerden, of Burnley, communicated through Mr. Henry Chapman; further experiments on condensation and re-evaporation of steam in a jacketed cylinder, by Major Thomas English, R.E., Superintendent, Royal Carriage Department, Woolwich.

THE Government of Victoria has definitely deputed Mr. James Stirling, Assistant Geological Surveyor in the service of the Government, to make a thorough and systematic survey and mapping of the coal districts in the colony. This step has been taken in consequence of the suggestions of Sir James Hector, the Director of the Geological Survey of New Zealand, who, during a recent visit to Victoria, examined the supposed coal-bearing seams, and reported favourably on them. The great drawback to Victorian prosperity so far has been the absence of coal deposits.

THE *Civil and Military Gazette* of Lahore says that Mr. Dauvergne has succeeded in erecting a monument to the memory of Mr. Dalgleish, where the latter was murdered at the foot of the Karakoram Pass two years ago.

DR. A. ALCOCK, of the Indian Marine, has been deputed to examine and classify the collections which the Indian Marine Survey has made over to the Imperial Museum, Calcutta, during the past few years.

THE cultivation of the Egyptian date-palm in India is to be tried on a large scale, and an order for over 700 off-sets and three maunds of seed has been sent to Egypt. It is intended that the consignment shall be distributed in the Punjab, Bombay, Madras, Rajputana, and Coorg, for experiment.

THE *Kew Bulletin* for October opens with a paper on a valuable fibre, largely used in this country under the name of Bahia piassava. This fibre is obtained from the leaf-stalks of a Brazilian palm known as *Attalea funifera*, Mart., and is used in the making of brushes and brooms. Some interesting remarks on the condition of the industry in Brazil, by Mr. W. S. Booth, are presented in the paper. In another paper there is a letter, addressed by Mr. D. Morris to the Colonial Office, on the treatment of seedling sugar-canes at Barbados, and of any that may be found in other sugar-producing colonies in the West Indies. The remaining subjects dealt with are cinchona in Jamaica; the commercial product called gambier, used by tanners; and the fibre industry at the Bahamas.

THE *Photographic Quarterly*, if we may judge from the first number, is likely to be of great service to all who interest themselves in the study of photographic methods. It opens with a series of hints, by the Rev. T. Perkins, on the production of pictures by photography. Among the other articles are "Chemistry and Photography," by C. H. Bothamley; "The Influence of Photography on Art, and its Consequences," by A. M. Rossi; "A Plea for Photogravure," by Major J. F. Nott; "Photo-micrography," by J. Hall-Edwards; and "New Method of Printing in Clouds in Lantern Slides," by Lionel Clark. A portrait of Mr. James Glaisher, F.R.S., President of the Photographic Society of Great Britain, accompanies the first number. There is also a view of Salisbury Cathedral from the Bishop's garden.

THE Pilot Chart of the North Atlantic Ocean for the month of October shows that September was very stormy, especially off the American coast and in the West Indies. Low barometer, accompanied by gales, prevailed along the transatlantic routes from the 4th to the 15th inclusive. The most notable disturbance was the West India hurricane, which seems to have originated east of the Windward Islands at the end of August, reaching Antigua and Martinique on September 2, and continuing with unabated force in a west-north-west direction until the 12th. The large area and the severity of this hurricane make it one of the most notable on record, and it is the subject of a special appendix, with charts, showing its behaviour over the ocean during each of ten days. The rapidity with which these charts have been published is, we believe, unequalled in maritime meteorology, and indicates, as stated in the remarks, the cordial support that the Washington Office receives from masters of vessels in its efforts to collect and utilize maritime data. There was a marked diminution of fog during the month, and an unusually large amount of ice as far as the 49th meridian, and even south of the 50th parallel.

THE appendix to the Bulletin of the New England Meteorological Society for the year 1888, shows that the number of stations constituting that weather service amounts to 172. The year was, on the whole, cool and wet, and some of the cyclones, of which 88 are classified according to the direction of their paths, were of great violence. Thunderstorms were very numerous, and in some cases destructive. A marked peculiarity of the year was the heavy rainfalls which occurred in the last six months. In the five months August to December the excess was nearly 11 inches. The greatest and least movements of the wind, as shown by anemometrical records, were in March and June respectively; the largest totals for the year were at Blue Hill Observatory.

AT the meeting of the Linnean Society of New South Wales on August 20, Mr. J. H. Maiden read an interesting paper on spinifex resin. The resin examined was a sample obtained by Mr. W. Froggatt near Derby, North-West Australia, last year, and presented by Sir William Macleay to Mr. Maiden. It is in flat cakes, about 3 inches in diameter, has a dirty bronze-green appearance, and a persistent disagreeable odour not easily described. It consists of vegetable *débris* (which may prove to belong to a grass) cemented with a yellowish-brown resin, and containing about 3 per cent. of fat. Mr. Froggatt states that it is employed by the natives as a cement for spear-heads, &c.; and the consistent testimony of the natives, as well as of the Europeans, is that it is obtained from the roots of spinifex grass (*Triodia irritans*, R.Br.). As far as the author knows, the extraction of resin from a grass has never previously been recorded. The resin isolated bears no resemblance to any other Australian resin known to the author.

A SCHEME is now being matured to establish regular training schools for surveyors in the Straits Settlements. The demand for surveyors is very great on the part both of the Government and of private individuals, and this demand is sure to increase with the rapid development of the Malay Peninsula.

TECHNICAL instruction is receiving a good deal of attention in the Central Provinces of India. Under the new scholarship rules, high school scholarships are tenable in the engineering and agricultural classes which were opened last year at Nagpore, and College scholarships have also been reserved for engineering students who desire to study in some Engineering College, or in any superior School of Forestry. At present, the classes at Nagpore are not well attended. In the engineering class, thirty students entered, but only eleven passed the first year's course. It is, however, expected that a large number will enter during the coming session. There was an average of twenty-five students in the agricultural class. In connection with the latter class, the students are compelled to work with their own hands at all the ordinary agricultural processes, and each receives a plot of land, which he is expected to till as directed. Besides practical agriculture, the students are taught mechanical and chemical analyses of soils and practical field-surveying. Gardening and carpentry are also taught. One of the greatest hindrances to the progress of this and similar institutions in India is the dislike of the Brahmins to any manual labour; but the authorities do not despair of overcoming this difficulty.

SOME Italian observers have been recently testing the senses of criminals; and they find these duller than in the average of people. Signor Ottolenghi, in Turin, found, last year, a less acute sense of smell in criminals; and he now affirms the same for taste, which he tested by applying bitter and sweet substances (strychnine and saccharine) in dilute solution to the tongue. He finds also the taste of the habitual criminal less acute than that of the casual offender, and a slightly more acute taste in male than in female criminals. Experiments with regard to hearing were made by Signor Gradenigo (also in Turin); and of 82 criminals he found 55 (or 67·3 per cent.) to have less than the normal acuteness, the greatest inferiority being in the oldest. In female criminals the relations were somewhat better: 15 out of 28 had hearing under the average. The limits of variations in acuteness also appeared to be much wider in criminals than in normal persons. Ear disease was common. Signor Gradenigo attributes these things to bad hygienic conditions of life, and vicious habits.

MESSRS. MACMILLAN AND CO. have issued Part 2, comprising Book II., of the fifth edition of Prof. M. Foster's "Text-book of Physiology." The work has been largely revised.

THE sixth edition of the well-known "Treatise on Dynamics of a Particle," by Prof. Tait and the late Mr. W. J. Steele (Macmillan), has been issued. The work was begun by Prof. Tait and Mr. Steele towards the end of 1852, and first appeared in 1856. "At Mr. Steele's early death," says Prof. Tait in the preface, "his allotted share of the work was uncompleted, and I had to undertake the final arrangement of the whole. In the subsequent editions it has derived much benefit from revision: first by Mr. Stirling of Trinity in 1865, then by Mr. W. D. Niven of Trinity in 1871, and by Prof. Greenhill of Emmanuel in 1878. It last appeared after a general revision by myself, with the assistance of Dr. C. G. Knott and of my colleague Prof. Chrystal. The present edition has been prepared by me, with the assistance of Dr. W. Peddie."

THE second volume of the "Geological Record" for 1880–84 (inclusive) has been issued. It is edited by Mr. W. Topley, F.R.S., and Mr. C. D. Sherborn. The subjects to which the lists of publications relate are physical and applied geology, petrology, meteorites, mineralogy, mineral waters, and palæontology. There is also a division entitled "General," and another deals with maps and sections. A carefully compiled index adds to the value of the work. Mr. Topley and Mr. Sherborn appeal to editors, publishers, and authors to aid them in future labours by forwarding copies of their publications, especially pamphlets separately published, and new series.

MESSRS. DULAU AND CO. will publish, in December, a "Catalogue of British Fossil Vertebrata," by Arthur Smith Woodward and Charles Davies Sherborn. The volume will consist of about 350 pages, and will tabulate the results of researches upon the British fossil Vertebrata since the time of Linnæus. The nature of the type specimen in each case is stated, and, whenever traceable, the museum or collection in which it is now preserved is mentioned. Special attention has been given to the distribution of the Pleistocene Mammalia.

WE have received from Napier, New Zealand, a copy of a pamphlet containing some papers on Maori folk-lore read before the Hawke's Bay Philosophical Institute by Mr. William Colenso. The first is entitled "Ancient Tide-lore and Tales of the Sea," and gives the Maori lore on the cause of the tides, on the sounding, or, as it is styled in Cornwall, the "calling," of the sea. These are followed by other Maori stories from the east coast of New Zealand, translated with explanatory notes. The whole forms one of the most charming contributions to folk-lore that have ever come under our notice.

IN his last Report to the Foreign Office on the agricultural condition of Colombia, the British Consul at Bogota says that the potato is the chief food of the people of the cold part of that country. Two principal varieties are known—namely, the criollas, which are red-skinned and orange-coloured inside, and the ordinary white potatoes. In 1865 the potato disease, which was unknown till that year, attacked the crops, and they have decreased very much in quantity since then. It is worthy of remark that the greater the altitude at which potatoes are planted (they are sometimes planted at a height of above 9000 feet on the mountains) the less tendency is there for the disease to break out, and at the greatest altitudes the disease is almost, if not quite, unknown. With regard to the cinchona industry, the Consul reports that in 1884 the Government of the Republic passed a law for the purpose of promoting the plantation of cinchona, india-rubber, and eucalyptus trees, and the President was authorized to award valuable prizes to the most successful growers of cinchona trees. The trees to be planted were to be of four species, *C. ledgeriana*, *C. officinalis*, *C. lancifolia*, and *C. pitayensis*, but, though the distribution of trees was free, the law has remained a dead letter; no new plantations have been made under its provisions.

A NEW series of experiments upon the vapour-density of aluminium chloride have been made by Profs. Nilson and Pettersson, with the view of deciding the somewhat vexed question of the valency of aluminium. Former experiments of the Swedish chemists led them to the conclusion that aluminium chloride does not become completely vaporized until a temperature of about 800° C. is attained, when the density of the vapour corresponds to the formula $AlCl_3$, this value (4·6) remaining constant until over 1000° C. On the other hand, Messrs. Friedel and Crafts, employing the method of Dumas, found that between 218° and 433° C. the density remains constant at a value (9·2) corresponding to the formula Al_2Cl_6. In order to render their experiments as unimpeachable as possible, Profs. Nilson and Pettersson have made their redeterminations at the lower temperatures by Pettersson and Ekstrand's modification of Dumas method, and have also been enabled by taking advantage of recent improvements in the construction of the Perrot furnace, to extend their observations to a white heat of 1600° C. Taking the higher temperature determinations by Victor Meyer's method first, the platinum apparatus used in the former experiments was discarded for glass and porcelain, as it has been shown that heated platinum has a slightly injurious effect upon the stability of aluminium chloride. Using glass apparatus heated in sulphur vapour (440° C.) the density was found to be 7·5. Heated still further in vapour of phosphorus pentasulphide (518°) the density diminished to 7·16. In stannous chloride vapour at 606° it became reduced to 5·34. The former results with the platinum apparatus at temperatures from 800° to 1000° showed that the density remains constant at about 4·6, corresponding to $AlCl_3$. Using the new Perrot furnace and a porcelain apparatus at 1400°, the density is still found to be not much reduced, 4·26; and at

1600°, the highest temperature attained, the value 4·08 was obtained. It therefore appears that for 600° over 1000° a very small amount of dissociation occurs, probably owing to the influence of a small platinum tube in which the chloride was introduced, as a minute quantity of an alloy of aluminium and platinum was afterwards found. Hence the molecules of $AlCl_3$ must be remarkably stable. The first of the experiments by the method of Dumas was conducted at the temperature of boiling nitrobenzene, 209°; at this temperature the density was 9·9. At the temperature of boiling eugenol, 250°, 9·62. At 301°, in vapour of diphenylamine, 9·55. In mercury vapour, at 357°, 9·34. In volatilized antimony tri-iodide, at 401°, 9·02; while at the temperature of boiling sulphur, the density, according to this method, had diminished to 8·79. From these results the Swedish experimenters conclude that the vapour-density of aluminium chloride decreases continuously and almost regularly up to 800°, when it becomes practically constant for four or five hundred degrees of temperature, and that although the value 9·2 is found somewhere between 200° and 400°, yet this value does not remain constant for a sufficient interval of temperature to enable us to assert the existence of molecules of the composition Al_2Cl_6.

THE additions to the Zoological Society's Gardens during the past week include two Common Marmosets (*Hapale jacchus*) from South-East Brazil, presented by Mr. Stanley Gibson; a Canadian Beaver (*Castor canadensis*) from North America, presented by Mr. J. R. Politzer; a Palm Squirrel (*Sciurus palmarum*) from India, presented by Mr. W. Tweedie; a Green Monkey (*Cercopithecus callitrichus*) from West Africa, presented by Mrs. E. Reeves; a Centipede, presented by Dr. C. H. Bousfield; a Rhesus Monkey (*Macacus rhesus*) from India, two Black-headed Lemurs (*Lemur brunneus*) from Madagascar, two Spur-winged Geese (*Plectropterus gambensis*) from West Africa, a Red and Yellow Macaw (*Ara chloroptera*) from South America, deposited; two Black Storks (*Ciconia nigra*), European, two Mantchurian Crossoptilons (*Crossoptilon mantchuricum*) from Northern China, purchased; a Puma (*Felis concolor*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OBSERVATORIES.—A list of the astronomical observatories of the world, by George H. Boehmer, has just been reprinted from the Smithsonian Report for 1886 (Government Printing Office, Washington, 1889). The work is the outcome of the preliminary account published by Prof. Holden, in 1879, a large amount of material having since been collected by correspondence. The various observatories are arranged under two heads—(1) American, (2) foreign—an alphabetical arrangement being adopted in each case. References are made to 78 American and upwards of 200 foreign observatories, including private observatories. In many cases the particulars are incomplete, but it is hoped that the publication will induce the directors of observatories to communicate to the author any further accounts and corrections which they may deem desirable. Latitudes and longitudes are given in nearly every case, and also a list of past and present directors. Descriptions of the more important observatories and their instrumental equipments are given.

A SPECTROSCOPIC SURVEY OF SOUTHERN STARS.—In a private letter, Mr. R. L. J. Ellery, F.R.S., writes:—"We have been making a spectroscopic *reconnaissance* of southern stars with a 'Maclean' spectroscope on our 8-inch refractor as a kind of 'jackal' list for the great reflector, with which we intend to make a systematic spectroscopic survey of stars between 40° S. and the South Pole. I am sending to the Royal Astronomical Society the first list of 100 stars." This is a most important step, and fills a gap which has been a disgrace to southern science.

THE ASTRO-PHOTOGRAPHIC CONFERENCE.—The *Comptes rendus*, containing the full proceedings of the above Congress, which met at Paris during the past month, have not yet been received. The following, however, are some of the points decided by the Permanent Committee:—

The centre of the plate is to be pointed not more than 5″ distant from the selected point in the heavens, the size of the plate to be 160 millimetres square. The size of the field adopted was 2° square, whilst the *réseau* is to be 130 millimetres square, with lines 5 millimetres apart.

The amount of overlapping decided upon was 5′. Vogel has undertaken the construction and verification of the *réseau*. The distribution of the work among the co-operating Observatories has been completed, and to Greenwich is allotted that from Declination +48 to +40.

Plate glass only must be used for the plates; the chemical formula, however, is left open. The sensitiveness for the Chart and for the Catalogue is to be the same. *Réseau* to be used in both series.

A series of standard plates will be prepared by the Paris Observatory, and the time of exposure must be adjusted so as to compare properly with these standards. There will be one or more *bureaus* established for such Observatories as cannot measure their own plates.

INTERNATIONAL CONGRESS ON CELESTIAL PHOTOGRAPHY.—There was a preliminary meeting of this Congress at Meudon on September 20, to consider the programme that had been drawn up by the Provisional Committee. A few slight alterations were made in the original scheme, but the details of the work were not entered into. It was, however, decided that the greatest latitude should be allowed in the choice of instruments, and that each observer should employ that instrument to which he was accustomed, having no regard to uniformity.

In order to indicate the spectroscopic work included in the programme, a change in the style of the Congress was agreed to. It is henceforth to be the "International Congress on Celestial Photography and Spectroscopy."

A LARGE detailed drawing of the Milky Way—the result of five years' labour—is now on view at the rooms of the Royal Astronomical Society, Burlington House. An explanatory note will be read at the next (November) meeting of the Society.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 *OCTOBER* 20–26.

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

At Greenwich on October 20

Sun rises, 6h. 35m.; souths, 11h. 44m. 47·5s.; daily decrease of southing, 9·8s.; sets, 16h. 55m.: right asc. on meridian, 13h. 41·3m.; decl. 10° 31′ S. Sidereal Time at Sunset, 18h. 52m.

Moon (New on October 24, 14h.) rises, 1h. 3m.; souths, 8h. 35m.; sets, 15h. 52m.: right asc. on meridian, 10h. 31·5m.; decl. 13° 56′ N.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. and declination on meridian. h. m.	° ′
Mercury..	5 42	11 10	16 38	13 6·8	7 1 S.
Venus ...	3 46	10 0	16 14	11 56·2	2 4 N.
Mars ...	2 42	9 18	15 54	11 13·7	6 26 N.
Jupiter ...	12 24	16 16	20 8	18 13·4	23 30 S.
Saturn ...	1 12	8 19	15 26	10 15·1	12 14 N.
Uranus ...	6 7	11 28	16 49	13 24·8	8 18 S.
Neptune..	18 26*	2 15	10 4	4 9·7	19 19 N.

* Indicates that the rising is that of the preceding evening.

Oct.	h.	
20 ...	1 ...	Saturn in conjunction with and 3° 1′ south of the Moon.
21 ...	6 ...	Mars in conjunction with and 3° 43′ south of the Moon.
22 ...	6 ...	Venus in conjunction with and 3° 48′ south of the Moon.
24 ...	11 ...	Mercury stationary.
24 ...	19 ...	Mercury at least distance from the Sun.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′		h. m.	
U Cephei	0 52·5	81 17 N.	Oct. 20,	2 25	*m*
			,, 25,	2 4	*m*
λ Tauri...	3 54·5	12 11 N.	,, 20,	20 28	*m*
			,, 24,	19 20	*m*
ζ Geminorum ...	6 57·5	20 44 N.	,, 24,	2 0	*M*
U Coronæ	15 13·7	32 3 N.	,, 24,	20 48	*m*
R Lyræ	18 52·0	43 48 N.	,, 21,		*M*
U Aquilæ	19 23·4	7 16 S.	,, 26,	20 0	*M*
η Aquilæ	19 46·8	0 43 N.	,, 21,	2 0	*M*
			,, 25,	21 0	*m*
S Sagittæ	19 51·0	16 20 N.	,, 26,	23 0	*m*
R Sagittæ	20 9·0	16 23 N.	,, 25,		*m*
X Cygni	20 39·0	35 11 N.	,, 20,	2 0	*m*
δ Cephei	22 25·1	57 51 N.	,, 23,	21 0	*M*
U Cassiopeiæ ...	23 52·8	50 46 N.	,, 26,		*M*

M signifies maximum: *m* minimum.

Meteor-Showers.

	R.A.	Decl.	
Near β Tauri	78°	32° N.	Swift.
,, ν Orionis	90	15 N.	The *Orionids.*
,, δ Geminorum ...	106	22 N.	Swift.
,, σ Ursæ Majoris ...	135	68 N.	Swift.

GEOGRAPHICAL NOTES.

DR. MOHN contributes to the *Scottish Geographical Magazine* a useful summary of our knowledge of the Barents Sea, between Spitzbergen and Novaya Zemlya. The depths of the Barents Sea contrast in a marked degree with those of the Norwegian and Greenland Seas. Between Jan Mayen and Norway, and between Greenland and Spitzbergen, there are depths of upwards of 2000 fathoms, but the bottom of the Barents Sea is found at depths under 300 fathoms. The transition from the great depths in the western part of the Northern Ocean to the shallows of the Barents Sea is marked by an imaginary line drawn between Western Spitzbergen and Tromsö. Here is a submarine plateau, having on its western wall a steep declivity towards the depths of the Northern Ocean, and on its eastern wall a relatively flat sea-bottom rising slowly towards the coasts of Norway, Russia, Novaya Zemlya, and Spitzbergen, and continuing towards the north-east, with only 100 fathoms of water, to between Spitzbergen and Novaya Zemlya. The adjacent Siberian Sea is also characterized by slight depths. The Barents Sea is therefore deepest in its western part. A depreesion of upwards of 200 fathoms in depth projects from here into the middle of the sea eastwards as far as the longitude of Vardö, the part of the bottom lying further east having depths varying between 200 and 100 fathoms, but more generally averaging the latter. The 100-fathom line runs very near the Norwegian coast; here the bottom consequently descends rather quickly from the coast-line. But from Kola, on the Murman coast, the 100-fathom line stretches direct to Novaya Zemlya, and continues in a sinuous direction to the north of this twin island. Further on we find it again in higher latitudes. It incloses Bear Island, and reaches the banks of Western Spitzbergen. On the eastern plain of the Barents Sea, where the depths are mostly a little over 100 fathoms, are found some slight elevations and depressions; the form of the sea-bottom is slightly undulating. As regards the material deposited on the bottom of the Barents Sea, we have acquired some knowledge from the researches of the Norwegian North Atlantic Expedition. The specimens consist of a peculiar sort of clay, different in description from that lying on the bottom of the deep Northern Ocean. Its chief constituent is silica (quartz); it is very poor in carbonate of lime, and is characterized by the existence in it of the shells of a small animal belonging to the Foraminifera, from which our zoologists have given it the name of the Rhabdammina clay. Its colour is dark green. It is probable that this material is derived from the quartz rocks of the surrounding countries, which, by means of the rivers, tides, currents, and drift-ice, have been spread over the sea-bottom. The salinity of the water of Barents Sea is slightly lower than that of the Norwegian Sea, particularly at the surface. The temperature of the water in the Barents Sea exhibits some contrast in its southern and its northern part. The mean annual temperature of the surface is 5° C. at the North Cape, 4° on the Murman coast, from 2° to 1° C. on the west coast of Novaya Zemlya, and 1° C. at Bear Island. In the month of August—the warmest for surface temperatures—the normal temperature of the sea is 9° C. at Söröen (Hammerfest), 8° to 6° and lower on the Murman coast, 5° to 1° at Novaya Zemlya, 2° at Bear Island, and 1° at the South Cape of Spitzbergen. In March—the coldest month for surface temperatures—the temperature of the sea is 2°·4 C. at the North Cape, 1°·4 at Vardö, 0° to – 2° at Novaya Zemlya, a little above 0° at Bear Island, and 1° at the South Cape of Spitzbergen. For the whole year as well as for the warmest and the coldest months, the surface water is consequently warmest at the coast of Finmarken, and coldest in the sea between Novaya Zemlya and Spitzbergen. At the depth of 100 fathoms we have 4° C. off Hammerfest, 3° off the Tana Fjord, 2° off the Fisher Peninsula (Rybatschi Ostrow), 1° off Kola, and 0° along a line running south to north from the 70th to the 75th parallels of latitude, and east to west along the last-named parallel. Similar curves show the other isotherms for 1° to 4°. In the above-named bay, bordered by the 200-fathom line, are found temperatures of from 1° to 3° above zero. At the sea-bottom, irrespective of its depth, the temperature is distributed in the following degrees. Off and near the coast of Finmarken it is upwards of 4° from Vardö to off Hammerfest, and 5° further west. From here the temperature decreases towards the east and towards the north. The current runs in the Barents Sea as a rule along the coast of Finmarken and the Murman coast eastwards, in the eastern part of the sea northwards, and in the northern part, between Novaya Zemlya and Spitzbergen, westward. Along the east coast of Spitzbergen the current sets southwards. The warm Atlantic current, a branch of the Gulf Stream (this name being taken in its widest sense) runs along the coast of Finmarken, curves on leaving the Murman coast towards the north, and turns then to the west towards Bear Island. It fills the sea down to the bottom with its temperate water. This is warmest in the southern branch running eastwards; and it becomes by and by, further on, cooled down by the neighbouring ice-cold water with which it mixes, and which from the northern regions is driven southwards and westwards. The surface of the sea between Spitzbergen and Novaya Zemlya is always covered with drifting ice. The larger animals in the sea being the objects of capture, live on smaller animals. The development and presence of these small organisms is greatly dependent on the temperature of the water. But their presence in a certain place, and to a certain time, depends upon the oceanic currents, these being as a rule so strong, and the locomotive powers of the small animals so small, that these must follow the movements of the currents. The animals living at or on the bottom get their food brought to them by means of the currents.

DR. JULIUS RÖLL, of Darmstadt, in the course of a mission of botanical exploration in the north-west of America, made an ascent in June 1888 of a summit in the Cascade Mountains, hitherto unnamed on our maps. The peak in question is situated under long. 121° 15′ W., and lat. 47° 22′ N., between two small lakes, and about 20 miles north of Easton on the Northern Pacific Railroad. The following is taken from a short account of his excursion contributed by Dr. Röll to the current number of *Petermann's Mitteilungen*. On June 19, in company with Herr Purpus, he made his way through the primæval forest, and over rising ground to the foot of the mountain, pitching his tent at an altitude of 5500 feet. The next morning the actual summit was ascended. It is composed of melaphyr, and many pieces of agate and rock crystal were found. The steep slopes are overgrown with ceanothus bushes, maples, and pines, between which bloom yellowish-red lilies (*Lilium philadelphicum*), and species of dark-red pentstemons. Three successive summits were climbed. The highest was estimated at 7500 feet; unfortunately the exact altitude could not be ascertained, as the traveller's barometer had become useless. The rocky crest of the mountain is covered with the *Selaginella rupestris*, pentstemons, phlox, pedicularis, several saxifrages, and some low umbelliferous plants, &c. Traces of bears, mooses, and mountain sheep were observed. The following day another ascent was made, and a magnificent view of the snow-covered Mount Tacoma obtained. Some weeks later, finding that the peak he had ascended was unnamed, Dr. Röll designated it "Mount Rigi," from the resemblance to the Swiss mountain of that name.

THE question of the influence of wind and rain in valley formation is discussed by Herr Rucktäschel in a short memoir contributed to the current number of *Petermann's Mitteilungen*, abstracted in the Proceedings of the Royal Geographical Society. The author, who has been pursuing his studies in Saxony and elsewhere, ascribes the "one-sidedness" which is observable in so many of the river valleys of Saxony to the action of rainy winds, in the absence of considerations arising from the configuration or composition of the soil. It has been observed that, in the case of most streams in this region flowing through soft sandstone, conglomerate, and diluvial soils, the east, north-east, or south-east bank presents a steep slope, while the opposite shore is flat. The cause is, according to Herr Rucktäschel, to be found in the action of the prevailing south-west, west, and north-west winds, which, heavily charged with rain, precipitate themselves almost at right angles upon the eastern sloping bank of a stream, washing away the soil in much greater quantity than from the western bank, and thus producing the one-sidedness referred to. Similar phenomena have been observed in some of the river valleys of Prussia and Bavaria. The author lays down the following conditions as necessary for the production of these effects by the westerly rain winds: (1) the soil must be composed of some loose or soft substance, (2) the valley must be eroded to a certain depth, (3) the volume of water in the stream must not be too great in proportion to that washed down the banks. For these reasons the phenomena can occur, as a rule, only along the smaller rivers, a large river; by the force of its own current, shapes its banks, and the influence of the prevailing rain winds is not so noticeable. Herr Rucktäschel visited England last summer to carry out researches there, but was unable to find any river-valleys suited for his purpose.

IT is reported from Hong Kong that the expedition of Mr. Rosset in the as yet unexplored districts of Annam, Cochin China, Cambodia, Siam, and the Laos States has been concluded. Much danger and many difficulties were encountered, but the result has been excellent, and Mr. Rosset will take back with him to Europe a valuable collection illustrative of the ethnology of the regions he has traversed. The journey was divided into three sections. The first comprised the Mekong River, the Chane and Bang-Came Rivers, to Stung-treng, in Siam, 104° to 106° long. and 13° to 14° lat. In this section the tribes of the Brouns or Bruns, the Kongs, and the Bennongs, were visited and studied. The second section of the journey as projected was from the mouth of the River Dongnai in Cochin China up to the frontier, covering the country between 104° and 106° long., and 11° and 12° lat., the special object of study being the ethnology of the Mois tribes. It was found, however, that the route was impracticable, the heavy rains and thickness of the jungle preventing the progress of the caravan, and the expedition was obliged to make a detour into the mountains of Binthuan. The third section of the journey again followed the Mekong River to Kratse, from thence branching east and north-east to the coast of Annam. Approaching Bung U the expedition followed a north-easterly direction to 13° lat. About 25 kilometres south-east of Kratse the River Pree Sé was passed, and the same river was crossed three times in the journey north-east to the coast; also a tributary river called the Sala. In this section the tribes of the Bennongs, Sliengs, Nhongs, and Ahongs were studied.

THE TEACHING OF SCIENCE.[1]

IN a Report presented to the Bath meeting the Committee gave an account of the replies they had received to a letter addressed to the head masters of schools in which elementary chemistry is taught. In this letter the Committee had asked for a report on the chemical teaching, and also for a statement as to the methods which had been found to render the teaching most effective as mental training. In commenting on these replies the Committee pointed out that the evidence which had been collected was conclusive in showing that much of the teaching of elementary chemistry is far from satisfactory, and needs to be considerably modified if it is to effect that valuable mental discipline which science teaching can afford.

The Committee are convinced that the high educational value of instruction in physical science has never been exhibited to its full advantage in most of our educational institutions. Nevertheless there exists already a considerable body of experience which proves that there is no more effective and attractive method of training the logical faculties than that which is afforded by a properly arranged course of instruction in physical science; by no other means are the powers of accurately ascertaining facts, and of drawing correct inferences from them, so surely developed as they are by the study of this subject.

Since the last meeting the Committee have been actively engaged in discussing the lines which a course of elementary instruction in chemistry should follow. The Committee were the more inclined to offer suggestions of their own, since they had learnt from the replies made to their letter of last year, by teachers in many of our well-known schools, that not only is the necessity for the adoption of improved methods fully recognized, but that teachers are anxious to receive advice and assistance in introducing them.

It cannot be too strongly insisted that elementary physical science should be taught from the first as a branch of mental education, and not mainly as useful knowledge. It is a subject, which when taught with this object in view, is capable of developing mental qualities that are not aroused, and indeed are frequently deadened, by the exclusive study of languages, history, and mathematics. In order that the study of physical science may effect this mental education, it is necessary that it should be employed to illustrate the scientific method of investigating Nature, by means of observation, experiment, and reasoning with the aid of hypothesis; the learners should be put in the attitude of discoverers, and should themselves be made to perform many of the experiments. The lessons ought to have reference to subjects which can be readily understood by children, and illustrations should be selected from objects and operations that are familiar to them in every-day life. Chemistry is particularly well adapted for affording this kind of instruction, and the Committee are of opinion that a course which is mainly chemical will be most useful in developing logical habits of thought.

Chemical inquiry involves, however, the use of various physical processes, and these are themselves of great value from the point of view from which the instruction is being given. It is also of great importance that the learners should become acquainted with the characteristic instrument of physical science, viz. measurement, and therefore quantitative processes should be largely made use of.

Having agreed as to the general principles on which a scheme of elementary instruction in chemistry should depend, the Committee gladly accepted the offer of Prof. Armstrong to draw up an account of such a scheme in sufficient detail to serve as a guide to those who have to provide such teaching. Without pledging themselves to accept all its details, the Committee consider that the scheme which Prof. Armstrong has prepared is in general accordance with their views as to what should constitute a course of elementary instruction in physical science.

With regard to the manner in which the scheme should be carried out, the Committee wish to lay stress on the following points. In order that the plan shall produce its full educational effect, the instruction should be commenced at an early age, and be extended to every child in the school. They do not desire to bring forward physical science as a substitute for any of the other principal subjects of study, but they ask that like these subjects it should be looked upon everywhere as a necessary part of education, and that it should receive a due share of the time devoted to school work. It is well known that at present science-teaching does not generally receive as much time and attention as is given to other studies. This was made clear in the Report of the Committee last year. It will be necessary to allot more time to the subject, and to employ a greater number of teachers. A teacher should not be required to give practical instruction to more than from fifteen to twenty pupils at one time, although the classes at lectures and demonstrations might be somewhat larger.

While the scheme now proposed may involve the employment of a larger number of teachers of natural science, on the other hand fittings and apparatus of the simplest description are all that will be absolutely needed, and the cost of maintenance will be relatively small.

The Committee are aware that the course of instruction now suggested is not in conformity with the present requirements of

[1] Report of the Committee, consisting of Prof. H. E. Armstrong, Prof. W. R. Dunstan (Secretary), Dr. J. H. Gladstone, Mr. A. G. Vernon Harcourt, Prof. H. McLeod, Prof. Meldola, Mr. Pattison Muir, Sir Henry E. Roscoe, Dr. W. J. Russell (Chairman), Mr. W. A. Shenstone, Prof. Smithells, and Mr. Stallard, appointed for the purpose of inquiring into and reporting upon the present methods of teaching Chemistry.

examining bodies. Its general adoption must therefore depend on their co-operation.

Suggestions for a Course of Elementary Instruction in Physical Science, drawn up by Prof. Armstrong.

Although the Committee is ostensibly charged to report as to methods of teaching *chemistry*, chemistry pure and simple is not what is required in schools generally, and therefore the Committee must be prepared to take into consideration and make recommendations as to a course of instruction preliminary to the natural science course proper, which in their opinion affords the most suitable and efficient preparation for later natural science studies.

After the most careful consideration of the question during at least ten years past, and after long holding the opinion that chemistry as usually understood is not the most suitable science subject for school purposes, I am now of opinion that a course which is mainly chemical is not only the best but also the only one possible if we are to secure all the objects aimed at in introducing science teaching into schools. Those objects are essentially: to train boys and girls to use their brains; to train their intelligence; to make them observing and reasoning beings, accurate observers, and accurate thinkers; to teach them to experiment, and that, too, always with an object—more frequently than not with what may be termed a logical object—not for mere descriptive purposes; to gradually inculcate the power of "doing," on which Charles Kingsley has laid so much stress, and which undoubtedly is the main factor of success in life. It can scarcely be gainsaid that through chemistry more than through any other branch of natural science it is possible to give precisely that kind of "practical" training so requisite at the present day, because the student is able to ascertain *by experiment* what are the exact facts, and thus to arrive independently at an explanation, whereas in the case of other sciences more often than not the explanation of necessity has to be given by the teacher.

Chemistry as usually taught loses greatly in educational value because pupils are told, more often than not, that "so and so is the case," instead of being taught *how it has been found out* that such is the case; indeed, that which has to be proved is usually taken for granted. Practical chemistry has hitherto, as a rule, been interpreted to mean the preparation of a few gases, &c., and the analysis of simple salts. Much useful information may be and is occasionally imparted during the performance of exercises of this kind, but the tendency undoubtedly is for analysis to degenerate into a mechanical drill, and, looking at the question from the practical point of view, and considering what is the general outcome of such teaching, probably we are bound to agree that the results thus far obtained are usually unsatisfactory. The difficulty, however, is to devise a course sufficiently simple both in conception and when carried into practice the cost of which is not too great; but with respect to this item of cost the Committee has to make clear to parents and teachers the claim of natural science to a fair and proportionate share of the total expenditure, which certainly has never yet been granted to it. By the introduction of such studies into the school course, a set of faculties are trained which it is all-important to develop, but which hitherto have been allowed to remain dormant, if not to atrophy, through neglect, and which, it is admitted by all competent authorities, cannot possibly be developed by any amount of attention paid to literary and mathematical studies. It is often not sufficiently clearly stated or understood that the advocates of natural science studies have no desire to displace any of the traditional subjects from the school course, and that all that they ask for is a fair share of the child's time, attention, and brains—a share proportionate to the effect which such studies can demonstrably produce in developing the mental faculties of the individual: that, in fact, natural science claims to co-operate and in no sense puts in an appearance as a rival.

STAGE I.—*Lessons on common and familiar objects.*

The first stage of instruction must be one of simple object-lessons, but these should have an intimate relation to the child's surroundings, and should be made the pegs on which to hang many a tale. Probably the most satisfactory and practical mode of commencing is to get children to draw up lists of familiar and common objects under various heads, such as

Natural objects.
Things used in building construction.
Things from which household furniture is made or which are in daily use.
Things used as clothing.
Food materials.

The children should be induced to describe these from observation as far as possible; to classify them according to their origin into mineral and animal and vegetable or organic; and occasion should be taken at this stage to give by means of reading lessons and demonstrations as much information as possible about the different things, their origin, how made, and their uses. It is obvious that in this way a great deal of geography and natural history (*Naturkunde*) might be taught in an attractive manner. Geikie's "Science Primer on Physical Geography" is the type of book which may be worked through with great advantage at this stage.

STAGE II.—*Lessons in measurement.*

This stage should be entered upon as soon as children have learnt the simple rules of arithmetic, and are able to add, subtract, multiply, and divide, and to use decimals.

Lineal measurements may be first made, using both an English foot-rule with the inch subdivided in various ways and a metric rule subdivided into millimetres. In this way the relation of the two scales is soon insensibly learnt.

Measurements of rectangular figures and the calculation of their areas may then be made.

After this the use of the balance may be taught, and the relation between the English and French systems may be learnt by weighing the same objects with the two kinds of weights. Use may then be made of the balance in determining the areas of irregular figures by cutting out rectangular and irregular figures from the same cardboard or thin sheet metal, and weighing these, &c.

Solid figures are next studied: a number of cubes made from the same wood having been measured, their volumes are then calculated, and the results thus obtained are compared with those which are obtained on weighing the cubes. The dimensions and weights of cubes made from different woods or other materials are then ascertained, and thus it is observed that different materials differ in *density*. The study of the *relative density* of things generally is then entered upon. The ordinary method is easily learnt and used by children, a suitable bottle being provided by filing a nick down the stopper of a common two-ounce narrow-mouth bottle; it may then be shown that the same results are obtained by the hydrostatic method of weighing in air and water, and it is not difficult to lead children to understand this latter method after they have determined the heights of balancing columns of liquids, such as turpentine, water and saturated brine, of which they have previously ascertained the relative density. These hydrostatic experiments are of value at a later stage in considering the effects of atmospheric pressure.

By determining the dimensions of a cube and the weight of the water which it will displace, an opportunity is afforded to point out that if the results are expressed in cubic centimetres and grammes respectively there is a practical agreement between the numbers, and hence, to explain the origin of the metric system of weights and the relationship between its measures and weights; the irrationality of the English system may then be explained.

The relative densities of a large number of common substances having being ascertained, the results may be tabulated and then the value of the data as criteria may be insisted on; as an illustration of their value, quartz, flint, sand, and gravel pebbles may be selected. The children having determined their relative densities, the agreement between the results may be pointed out and the identity of the material explained. By drawing perpendiculars corresponding in height to the densities of various substances, a graphic representation is obtained which serves to bring out the value of the graphic method of representation.

A very valuable exercise to introduce at this stage is based on the well-known fact that in certain conditions of the atmosphere things appear moist; a muslin bag full of seaweed may be hung up under cover but freely exposed, and may then be weighed daily at a given time; simultaneously the state of the weather, direction of the wind, the height of the barometer, and the wet and dry bulb thermometer may be noted; on tabulating the results, and especially if the graphic method be employed, the variations and their relationship will be noticeable.

The thermometer, having thus become a familiar instrument, may be used to examine melting ice and boiling water; the construction of both the Centigrade and Fahrenheit thermometer may then be explained, and the effect of heat on bodies made clear. The density of ice and of water at various temperatures may then be determined, a Sprengel tube—which is easily made—being used for warm water; the bursting of pipes in winter, the formation of ice on the surface of water, &c., may then be explained. Afterwards simple determinations of the heat capacity of a few metals, &c., and of the latent heat of water and steam, may be made in accordance with the directions given in a book such as Worthington's "Practical Physics."

STAGE III.—*Studies of the effect of heat on things generally; of their behaviour when burnt.*

As it is a matter of common observation that heat alters most things, the effects of heat on things generally should be studied; in the first instance qualitatively, but subsequently, and as early as possible, quantitatively. Bits of the common metals may be heated in the bowl of an ordinary clay pipe plunged into a clear place in any ordinary fire, or in such a pipe or a small iron spoon over a gas flame. The difference in fusibility is at once apparent, and in the case of metals like iron and copper it is noticeable that although fusion does not take place, a superficial change is produced; the gradual formation of a skin on the surface of fused lead and tin is also easily perceived. Observations like this become of great importance at a later stage, and indeed serve to suggest further experiments: this is a point of special importance, and from the beginning of this stage great attention should be paid to inculcating habits of correct observation; the effect should first be recorded by the pupil, the notes should then be discussed and their incompleteness pointed out, and they should afterwards be re-written. The fusibility of substances which are not affected when heated in the tobacco pipe may be tested by heating them with a Fletcher gas blow-pipe on charcoal; and by heating little bits of wire or foil in such a flame it is easy for children to discover the changes which metals undergo when burnt, especially in cases such as that of zinc or copper or iron.

The further study of the effects of heat should be quantitative, and may well commence with water. It being observed that water disappears on heating, water may be put into a clock glass or glass dish placed on a water bath (small saucepan); it evaporates, and it is then observed that something is left. A known quantity of water by weight or volume is therefore evaporated and the residue weighed. This leads to the discovery that water contains something in solution. The question then naturally arises, What about the water that escapes? so the steam is condensed and the distilled water evaporated. The conception of pure water is thus acquired. An experiment or two on dissolution—using salt and sugar—may then be introduced, a water oven or even an air oven (a small Fletcher oven) kept at a known temperature being used, and the residue dried until the weight is constant. Rain and sea-water may next be examined; the results afford an opportunity of explaining the origin of rain and of accounting for the presence of such a large quantity of dissolved matter in sea-water. Then the various common food materials may be systematically studied, commencing with milk; they should first be dried in the oven, then carbonized and the amount of char determined, then burnt and the percentage of ashes determined. A small platinum dish, 15 to 20 grammes in weight, is required for these experiments, and a gas muffle furnace is of the greatest use in burning the char and in oxidizing metals. In addition to the discipline afforded by such experiments a large amount of valuable information is acquired, and the all-important fact is established that food materials generally are combustible substances. Afterwards mineral substances are examined in a similar manner, such as sand, clay, chalk, sulphur, &c., and then metals such as lead, copper, tin, and iron may be studied; their increase in weight is in striking contrast to the inalterability of substances like sand and salt, and the destruction of vegetable and animal substances. Chalk, from which lime is made by burning, is found to occupy a middle position, losing somewhat in weight when strongly heated. The exceptional behaviour of coal among mineral substances, and of salt among food materials, is shown to be capable of explanation, inasmuch as coal is in reality a vegetable and salt a mineral substance; but sulphur remains an instane of exceptional behaviour requiring explanation. It is not exceptional in being combustible, as metals like magnesium and zinc are combustible, but in affording no visible product. The smell of burning sulphur, however, serves to suggest that perhaps, after all, there is a something formed which is an invisible substance possessed of an odour, and then follows quite naturally the suggestion that perhaps in other cases where no visible or perceptible product is obtained—as on burning charcoal, for instance—there may nevertheless be a product. Whereas, therefore, in Stage I. the pupil will have learnt to appreciate the existence of a great variety of substances, and will have gained the power of describing their outward appearance more or less fully; and in Stage II. having learnt how to measure and weigh, will acquire the habit of determining by measurement certain properties of substances, and will thus be in a position to express in exact terms the kind of differences observed; in Stage III. the pupil will be led to see that profound changes take place on burning substances, and that these changes involve something more than the destruction of the things burnt. The foundation is thus laid for the study of change, *i.e.* chemical studies proper.

STAGE IV.—*The problem stage.*

Many of the changes observed in the course of the experiments made in Stage III. might be examined and their nature determined, but the best to take first is a very familiar case, that of the rusting of iron.

PROBLEM I. *To determine what happens when iron rusts.*—The pupil *must* be led in the first instance to realize that a problem is to be solved, and that the detective's method must be adopted and a *clue* sought for. It is a familiar observation that iron rusts, especially when wet; what happens to the iron, why does it rust, is the iron alone concerned in the change? No information can be gained by looking at it—perhaps the balance which has brought to light so much in Stage III. may be of service, so the iron is allowed to rust in such a manner that any change in weight can be observed. A few grammes of iron filings or borings are put on to a weighed saucer or clock glass along with a bit of stiff brass or copper wire to be used as a stirrer; the iron is weighed, then moistened and exposed under a paper cover to keep off dust, preferably in a warm place; it is kept moist and occasionally stirred. After a few days it is dried in the oven and then weighed. The weight is greater. *Something from somewhere has been added to the iron.* Thus the clue is gained. Where did this something come from? The fact that when a tumbler, for instance, is plunged mouth downwards into water the water does not enter, and that on gradually tilting the tumbler to one side something escapes—viz. air—at once affords a demonstration of the presence of air in the space around us. The iron rusted in this air, but was kept moist, so it may have taken up the something from either the air or the water. To ascertain whether the air takes part in the rusting, some iron borings are tied up in a bit of muslin and the bag is hung from a wire stand placed in a (jam) pot full of water and a so-called empty (pickle) bottle, which in reality is full of air, is inverted over the iron; in the course of a few hours, as the iron rusts, the water is observed to rise until it occupies about one-fifth of the jar (determined by measuring or weighing the water); the something added to the iron during rusting appears therefore to come from the air, and the all-important fact is thus discovered that the rusting is a change in which not the iron alone, but also the air, is concerned. The experiment is several times repeated, fresh iron being used with the same air and the same iron put in succession into fresh portions of air, but the same result is always obtained: whence it follows that whatever it is in the air which takes part in the rusting, the air as a whole is not active. The changes previously observed to take place when iron, copper, lead, zinc, &c., were heated in air, are then recalled; as the metals were found to increase in weight, it would appear probable that in these cases of change also the air was concerned.

These results at once suggest the question, What is air? So much having been learnt by studying the change which iron undergoes in rusting, other changes which happen in air therefore are next studied.

PROBLEM II. *To determine the nature of the changes which take place on burning substances in air.*—The use of phosphorus is introduced by reference to a match. Phosphorus is then burnt under a bell jar over water and the result noted: the disappearance of some of the air again shows that the air is concerned. The fact that phosphorus smokes when taken out of the water in which it is always kept suggests that some change is going on, so a stick of phosphorus is exposed in air as in the previous experiment with iron: soon one-fifth has disappeared, and the phosphorus then ceases to smoke. The *quantitative* similarity of the two results suggests that iron and phosphorus behave alike towards air, and *vice versâ*, and serves to confirm the idea that some constituent of the air present only to the extent of about one-fifth is active. But nothing is to be taken for granted, so iron is exposed in the phosphorus-air residue and phosphorus in the iron-air residue: as no change occurs, there is no room left for doubt. Recalling the experiments in which various metals were burnt in air, in order to determine whether in these cases the same constituent of the air was concerned in the change, air from which the active constituent has been removed by means of phosphorus is passed through a heated tube containing bits of the metals: no change is observed, so it is evident that as a rule, if not always, one and the same constituent of air is concerned. The experiments with iron and phosphorus, although they show that the air is concerned in the changes which are observed to take place, do not afford any information whether or no the water which is also present is concerned in the change. Phosphorus is therefore burnt in a "Florence" flask closed with a rubber stopper: on removing the stopper under water some water enters, and by measuring this and the amount of water which will fill the flask the same result is obtained as in the previous cases. To be certain whether in this case anything enters or escapes from the flask it is weighed before and after the phosphorus is burnt. There is no change in weight. But does nothing escape? Yes, much heat; whence it follows that heat is not material—that, although some of the air disappears, it is merely because it has become affixed to or absorbed by something else. This has been proved in the case of the rusting iron and the burnt metals. To obtain indisputable evidence in the case of the phosphorus this is burnt in a current of air in a tube loosely filled with asbestos to retain the smoke: the weight is found to increase. The observation that the phosphorus ceases to burn after a time suggests the introduction of a burning taper into the residue left by iron, &c.; it is found to be extinguished. Then a candle and subsequently a gas flame may be burnt in a bell jar full of air over water. Reversed combustion may then be demonstrated in order to fully illustrate the reciprocal character of the phenomena. Thus it is ascertained that all ordinary cases of combustion are changes in which the air, and not the air as a whole but a particular constituent, is concerned, and no doubt remains that the same constituent is always active, but active under different conditions; it is realized also that the production of heat is the consequence of the union of the substance burnt with the active substance in air. The experiment of exposing phosphorus in air affords the opportunity of demonstrating the evolution of heat even in a case where no visible combustion occurs, as the phosphorus is always observed to melt. At this stage careful note should be taken of the appearance of the different products of combustion, and of a change such as that which occurs when the product from phosphorus is exposed to the air.

PROBLEM III. *To separate the active from the inactive constituent of air.*—It now has become of importance to get this active constituent of the air by itself, and the question arises whether it cannot be separated from one of the metals or other substances with which it has been found to combine. The pupil is therefore told to collect information about the different substances formed by burning metals, &c.,—whether they can be obtained in sufficient quantity to work with, &c. Iron rust and iron scale are easily obtainable, and so is copper scale; zinc is burnt to produce zinc white, which is used as paint; lead is also burnt on a large scale, and in this case it appears that one or other of two substances is formed—litharge at a high temperature, red lead at a lower temperature. This peculiarity of lead suggests the study of the two products in the hope of discovering the clue to a method. Weighed quantities of the litharge and red lead are heated; it is observed that only the latter changes in appearance and that it loses weight. But what does it lose? It was formed by merely roasting lead in the air, and the something which it loses must therefore have been derived from the air. If the red lead is heated in a tube a gas is given off which is collected and tested—how? With a taper or glowing splinter as it is to be supposed that the gas will support combustion if, as is to be expected, it is the active constituent of air. The *discovery* of the active constituent of air is thus made! If air consist of this gas and that which remains after exposing phosphorus or iron in air, then by adding to such residual air as much of the gas from red lead as was withdrawn, air should be re-obtained; this is found to be the case. The names of the two gases are now *for the first time* stated, and an easy method of preparing oxygen is demonstrated, such as that of heating chlorate, but without any explanation. The conclusion previously arrived at, that probably in all the cases previously studied of changes occurring in air, the oxygen is the active substance, may now be verified by burning or heating in oxygen the substances which had been burnt in air.

So much having been learnt of the chemistry of air, the study of the pressure exercised by air may next be taken up, and the common pump, the force pump, the barometer, and air currents may be discussed and explained. Nowadays the charts given in the daily papers, and the Ben Nevis and glycerine barometer readings quoted in the *Times* make it particularly easy to explain the barometer. The pupils should be led to make barometer curves.

PROBLEM IV. *To determine the composition of chalk.*—The discovery of the *composition* of the air in the course of experiments made with the object of determining the nature of certain changes naturally suggests that the attempt be made to ascertain the composition of other things by studying the changes which they undergo. Chalk is known to give lime when burnt, and experiments made in Stage III. have indicated that chalk loses something when burnt—the idea that an invisible something is given off is especially probable after the experiments with red lead have been made; so it is decided to heat chalk strongly, but before doing this chalk and lime are examined comparatively. Chalk is not observed to be altered by water; on shaking it up with distilled water and evaporating some of the filtered liquid in a weighed dish, very little residue is obtained—so it is established that it is but very slightly soluble in water. Lime is slaked, weighed quantities of lime and water being used; the retention of a considerable amount of water, even after exposing the slaked lime in a drying oven, shows that the slaking involves a definite change in composition—that slaked lime is lime and water. The solubility of the lime is next determined, and found to be considerably greater than that of the chalk. It is found that chalk is but very slightly altered in weight when heated over a gas flame, and that it is only when it is strongly heated that it is converted into lime: so the chalk is strongly heated in an iron tube in a Fletcher blow-pipe furnace, when gas is freely given off. This is tested with a taper, which it extinguishes, so it cannot be oxygen, but may be nitrogen; if it be nitrogen, when mixed with oxygen in the proportion of 1 to 4, it should give air, but this is found not to be the case; so evidently it is a peculiar gas, and may be called chalk gas. If chalk consist of this gas and lime it should be possible to reproduce chalk from them; so the gas is passed through a small weighed tube containing lime, and the tube is found to get heavier. But lime and chalk are so much alike that it is difficult to say that chalk is formed; perhaps dissolved lime will act similarly; the gas is therefore passed into or shaken up with lime water. The precipitate which forms looks like chalk and probably is, but this remains to be decided. The discovery of this behaviour of chalk gas, however, is important as affording a means of again comparing the gas from chalk with nitrogen. In working with lime water it is scarcely possible to avoid noticing that a film forms on its surface; by exposing a quantity of the lime water a considerable amount of the precipitate is obtained; its resemblance to chalk is noted, and the possible presence of chalk gas in air is thus suggested; but in view of the absence of proof of the identity of the precipitates with chalk a decision is reserved. The discovery is made, however, that air contains something besides oxygen and nitrogen.

It being thus established that chalk consists of two things, lime and chalk gas, at this stage it is pointed out how firmly these two constituents hold to each other in the chalk. The absorption of the gas by the lime—its entire disappearance in fact—is commented on. Accurate determinations of the loss of weight on heating crystallized chalk (calc-spar) should at this stage be carried out before the class, if not by the pupils, so that the numbers may be quoted and that it may become impressed on them that the proportions in which the lime and chalk gas are present is constant. Their attention may be recalled to the oxides previously studied, it being pointed out that on inspection these afford no indication that they contain oxygen; that here again the gas entirely loses its individuality on entering into union or combining. That oxides contain their constituents in fixed proportions may be demonstrated experimentally by oxidizing finely-divided copper and determining the increase in weight, lime being used as drying agent. In this way the characteristics of *compounds* are elucidated. Then the comparison may be made with air, and the fact made clear that it behaves as a mere mixture. Still no reference should be made to elements.

PROBLEM V. *To determine what happens when organic substances are burnt.*—The experiments thus far made have shown that phosphorus and a number of metals burn in the air because they combine with the oxygen, forming oxides, heat being given out *as a consequence*; but that chalk when burnt is split up or decomposed into lime and chalk gas, this result being a consequence of the heating alone, the air having nothing to do with it. It remains to ascertain what happens when organic substances are burnt, as these give no visible product beyond a little ashes. As in all cases when vegetable or animal substances are burnt a certain amount of "char" is obtained, which then gradually burns away, charcoal or coke is first studied. It having been discovered that the oxygen in air is the active cause of burning in many cases, it appears probable that the air is concerned in the burning of charcoal, coal, &c. As when once set fire to, these continue to burn, the charcoal is at once heated in oxygen: it burns, but no visible product is formed; it therefore follows that if the charcoal is oxidized the oxide must be an invisible gas. How is this to be tested for? What gases are already known to the pupil? How are these distinguished? Oxygen is excluded. Is it perhaps nitrogen, and is not perhaps the nitrogen in air merely used-up oxygen as it were, produced by the burning of organic substances? Or is it perhaps that gas which was found in the air along with oxygen and nitrogen, and which turned lime water turbid? This last being an easy test to apply is at once tried; the lime water is rendered turbid, and so to leave no doubt a sufficient amount of the gas is prepared and passed into lime water, the precipitate is collected, and the loss it suffers on heating is determined and found to agree with that suffered by the precipitate prepared from chalk gas. Finally, to ascertain whether the product is really heavier than the charcoal burnt, as in the case of the metals previously studied, the charcoal is burnt in oxygen in a tube connected to a flask containing milk of lime with a lime-drying tube attached to it; the tube is weighed before and after burning. Thus the discovery is made that chalk gas is an oxide of carbon, and that chalk consists of at least three things.

It may be objected that to make the experiment in this manner takes too much time; but to this it may be answered that such experiments are precisely of the kind of those made in actual practice, and that they exercise a most important influence in teaching the pupils to take nothing for granted, never to jump at conclusions, and to rest satisfied if they progress surely, however slow the advance may be.

A number of organic substances may now be burnt, and the gas passed into lime water; chalk gas is found in every case to be a product, and hence the presence of a common constituent—carbon—in all is established. In making these experiments the formation of a liquid product is observed, so it is evident that chalk gas is not the only product, or carbon their only constituent.

Food materials generally having been found to contain "carbon," as they are obviously in some way destroyed within the body, and it is known that air is necessary for life, the question arises, what becomes of food, and why is air necessary for life? Is the food, perhaps, in large part "burnt up" within the body, thus accounting for the fact that our bodies are always warm? The characteristic product of combustion of carbonaceous substances is therefore tested for by breathing into lime water. The discovery thus made affords an opportunity for a digression and for explaining how plants derive their carbon from the air.

* PROBLEM VI. *To determine what happens when sulphur is burnt.*—From the results of the experiments with carbon, it appears probable that the disappearance of sulphur when burnt is also really due to its conversion into a gaseous oxide, so it is kindled and introduced into oxygen: if it be burnt over water in a bell jar in a spoon passing through the stopper (a rubber cork), the water is seen to rise; if, on the other hand, it be burnt in a dry flask closed by a rubber cork carrying a gauge-tube, as suggested by Hofmann,[1] the volume is seen to be almost unchanged after combustion. It follows, therefore, that the sulphur and oxygen unite and form a soluble product. Sulphur is next burnt in a tube in a current of oxygen, and the gas is passed into water; a solution is thus obtained having the odour of the gas and sour (acid) to the taste. The fact that carbon and sulphur —both non-metals—behave alike in yielding gaseous oxides suggests that a comparison be made of their oxides; so the acid solution is added to lime water; a precipitate is formed, which redissolves on adding more of the sulphur gas solution; on the other hand, on adding the lime water to the acid liquid, this latter after a time loses its characteristic smell. There can be no doubt, therefore, that the sulphur gas does in some way act upon the lime. The experiment is then made of burning the sulphur in a weighed tube containing lime; the weight increases, so that no doubt remains that sulphur, like carbon, forms an oxide when burnt. The discovery that the addition of more of the sulphur oxide leads to the dissolution of the precipitate which it first forms in lime water, suggests trying the effect of excess of the carbon oxide on the lime water precipitate; this is done, and the discovery is made that the precipitate gradually dissolves. The solubility of the new substance may then be determined by passing the gas into water containing chalk in suspension, filtering, and evaporating. This leads to the observation that a precipitate is formed on heating the liquid, and this is soon found to be chalk. An opportunity is thus afforded of explaining the presence of so much "chalk" in water; of demonstrating its removal by boiling and by lime water; and the effect it has on soap.

The observation that the oxides of both carbon and sulphur combine with lime suggests trying whether the one will turn out the other; so the solution of the sulphur oxide is poured on to chalk: effervescence is observed, and on passing the gas into lime water a precipitate is obtained. The production of this effect by the *acid* solution suggests trying common vinegar—a well-known *acid* substance. This also is found to liberate chalk gas, and the discovery of an easy method of preparing chalk gas is thus made. The oxide formed on burning phosphorus, having previously been found to give an acid solution, is tried, and it is found that it also liberates chalk gas. As a good deal of vinegar is found to give very little chalk gas, the question arises, Are there not acids to be bought which will have the same effect and are stronger and cheaper? On inquiry it is found that sulphuric acid or oil of vitriol, muriatic acid or spirits of salts, and nitric acid or aquafortis may be bought, and that these all act on chalk. The behaviour of chalk with acids affords a means of testing the lime water precipitate obtained in working out Problems IV. and V. In this manner the pupil is led to realize that certain agents may very readily produce effects which are only with difficulty produced by heating—that the *chemical agent* may produce very powerful effects. The ready expulsion of the carbon oxide of chalk suggests that other substances not yet studied, such as the metals, when treated with acids may behave in a special manner which will afford information as to their nature. At this point, prior to making the experiments with the acids, an explanation may be given of the names *oil of vitriol*, *spirits of salts*, and *aquafortis*; the processes by which they are made may be described and illustrated, without, however, any attempt being made to explain them from the chemical point of view. The sulphuric acid should be made from green vitriol, and its behaviour on dilution should be demonstrated as well as its use as a drying agent.

PROBLEM VII. *To determine what happens when metals are heated with acids.*—Iron, zinc, lead, tin, copper, and silver may be taken. On pouring diluted oil of vitriol on to iron or zinc, the metal dissolves with effervescence; the gas is collected, and when tested is found to burn. Thus a new gas is discovered, differing from all which have previously been studied, inasmuch as it is combustible; in order not to interrupt the study of the action of acids on metals, however, its further examination is postponed for a while. Resuming the experiments with metals, lead, tin, copper, and silver are found not to be acted upon by diluted oil of vitriol.

Muriatic acid, in like manner, dissolves iron and zinc and also tin with effervescence, and the gas which is given off in each case exhibits the same behaviour as that obtained from iron or zinc and diluted oil of vitriol. Lead, copper, and silver are not appreciably affected.

Aquafortis is found to dissolve not only iron and zinc but also copper, lead, and silver, and to convert tin into a white substance —to attack all the metals in fact, thus justifying its name. The gas which is given off as the metal dissolves is observed to be coloured; when it is collected over water, however, it is seen to

[1] By burning carbon also in this way a most effective demonstration is given of the fact that no loss or gain of matter attends the change, and that only heat escapes; the results in the case of carbon and sulphur are particularly striking, as the products are gaseous and invisible.

be colourless, and to become coloured on coming into contact with air—oxygen and nitrogen are, therefore, added to portions of the gas over water. In this manner, not only is a new gas discovered, but also a test for oxygen; and opportunity is afforded of here calling attention to the fact that air behaves exactly as oxygen, that the oxygen in air appears to be unaffected by its association with nitrogen—that, in fact, it is uncombined. From these experiments it is obvious that metals and acids interact in a variety of ways. Finally, the dissolution of gold and platinum by aqua regia may be demonstrated.

PROBLEM VIII. *To determine what happens when oxides are treated with acids.*—In the course of the previous experiments a number of oxides have been prepared by burning various metals in air; these are found to be unchanged by water. The discovery that acids act on metals suggests a trial of the effect which acids will have on their oxides; so the oxides of zinc, iron, copper, and lead are submitted to the action of the three acids previously used. Sulphuric acid is found to dissolve zinc oxide, iron rust, and copper oxide, but no gas is evolved; excess of the oxide may be used, and the filtered liquid concentrated; the crystals which separate may be examined and compared with those obtained by dissolving the metal in sulphuric acid, &c. Litharge apparently is not changed by sulphuric acid, but red lead is, although not dissolved. Muriatic acid being used, all the oxides are found to dissolve, and in the case of red lead a greenish-yellow gas is given off possessing a most disagreeable smell: this is noted as a case for study. The product from the lead oxides is observed to crystallize out from the hot liquid on standing, so the undissolved original product is boiled up with water, and the solution is filtered, &c. Attention is thus directed to the difference in solubility of the products. Next, aquafortis is used; again all are dissolved, except the red lead, which, however, is obviously altered. In the case of the lead oxides the product is again less soluble than those afforded by the other oxides, but more soluble than the product obtained on using muriatic acid. The pupil has already been led to realize that of two substances capable of acting on a third, such as chalk gas and sulphur gas, which both combine with lime, one may be the stronger, and may turn out the other, sulphur gas turning out chalk gas from chalk. A comparison of the three acids with the object of ascertaining which is the strongest is therefore suggested: the metal or oxide is dissolved in one of the acids, and the others are then added. No positive result is obtained in case of zinc, iron, or copper, but the solution of lead in nitric acid is precipitated by muriatic and by sulphuric acid; the former precipitate is found to dissolve in boiling water and to crystallize out in exactly the same way as the substance obtained from lead oxide and muriatic acid. The sulphuric acid product is found to be almost insoluble in water, and also in muriatic and nitric acids: these observations make it possible, by examining the behaviour towards muriatic and nitric acids of the products of the action of sulphuric acid on the lead oxides, to establish the fact that the product is the same whether lead be dissolved in nitric acid and sulphuric acid be then added, or whether either of the oxides be treated with sulphuric acid. It is further evident that those acids which give difficultly soluble or insoluble products act with difficulty if at all on the metal. Other metals besides those mentioned may be now studied, and, a solvent being found, the acids which do not dissolve the metal may be added to the solution. In this way, for example, the chloride test for silver is discovered.

In experimenting with acids the pupils can hardly fail to stain their clothes and their fingers. The observation that acids alter colours serves to suggest experiments on the action of acids on colours, especially those of leaves and flowers. The use of litmus, methyl-orange, cochineal, &c., may then be explained. As various oxides have been found to "neutralize" acids, the study of their effect on the colours altered by acids is suggested. Lastly, a few experiments with vegetable and animal substances, sugar, &c., may be made, which demonstrate the corrosive action of oil of vitriol and aquafortis.

PROBLEM IX. *To determine what happens when the gas obtained by dissolving iron or zinc in sulphuric or muriatic acid is burnt.*—The gas has been observed to burn with a smokeless, odourless flame. To ascertain whether, as in all other cases of combustion previously studied, the oxygen of the air is concerned in the combustion, a burning jet of the gas is plunged into a dry cylinder full of oxygen, in which it is not only seen to continue burning, but it is also noticed that drops of liquid condense on the cylinder above the flame; this immediately suggests that the product is a liquid. The jet is found to be extinguished in nitrogen, so evidently when the gas burns it forms an oxide. The experiment is repeated, and the gas burnt in a bell jar full of oxygen over water: the water rises as the combustion proceeds, proving that the oxygen is used up. To collect a sufficient quantity of the product for examination, the dried[1] gas is burnt at a jet underneath a Florence flask through which a stream of cold water is allowed to circulate: the neck of the flask is passed through the neck of a bell jar and the flask and bell jar are clamped up in an inclined position, so that the liquid which condenses may drop into a small beaker placed below the rim of the jar. What is the liquid? It looks very like water, and is without taste or smell. Is it water? How is this to be ascertained? What are the properties of water? The knowledge previously gained here becomes of importance. It has been observed that frozen water melts at 0° C., that water boils at 100°, and that one cubic centimetre weighs one gramme at 4° C.; so the liquid is frozen by the ice-maker's mixture of ice and salt, a thermometer being plunged into it so that the solid ice forms on the bulb: the melting-point is then observed. Subsequently the boiling-point is determined, a little cotton-wool being wrapped around the bulb of the thermometer. Lastly, the density of the liquid may be determined. It is thus established that the gas yields water when burnt, and the name of the gas may now *for the first time* be mentioned and explained. The results thus obtained leave little doubt that water is an oxide of hydrogen; but in order to place this beyond doubt it is necessary to exclude nitrogen altogether. How is this to be done? Red lead is known to consist of lead and oxygen only, and readily parts with a portion at least of its oxygen; so dried oxygen is passed over red lead, which is then gently heated. Again a liquid is obtained which behaves as water, so there can be no doubt that water is an oxide of hydrogen. Water is not obtained on merely mixing oxygen and hydrogen; it is only produced when combustion takes place. To start the combustion a flame is applied to a small quantity of a mixture of the two gases: a violent explosion takes place. An opportunity is here again afforded of calling attention to the entire change in properties which takes place when the compound is formed. On heating red lead in hydrogen, lead is obtained, although on heating it alone it loses only a portion of its oxygen, and the "reduction" takes place very readily; evidently, therefore, hydrogen is a powerful agent. This observation suggests further experiments. Will it not be possible to remove oxygen by means of hydrogen from other oxides which are not altered on heating? and will not other combustible substances besides hydrogen remove oxygen from oxides?

PROBLEM X. *To determine what happens when hydrogen and other combustible substances are heated with oxides.*—Zinc oxide, iron rust, and copper oxide are now heated in a current of hydrogen: the first remains unaltered, the other two are seen to change, a liquid being formed which it cannot be doubted is water; the copper oxide evidently becomes reduced to copper. Is the iron rust similarly reduced to the metallic state? How is iron to be tested for? Iron is attracted by the magnet, and dissolves in diluted oil of vitriol with evolution of hydrogen. Applying these tests, no doubt remains that the iron rust is deprived of its oxygen.

Litharge and copper oxide may then be mixed with soot or finely powdered charcoal and heated in tubes; gas is given off which renders lime water turbid, and metallic lead or copper is obviously obtained. It is thus established that some but not all oxides may be deprived of their oxygen by means either of hydrogen or carbon. Opportunity is here afforded of explaining the manufacture of iron.

Several dried combustible organic substances, sugar, bread, and meat, may now be burnt with copper oxide in a tube the fore part of which is clean and is kept cool: liquid is seen to condense, while "chalk gas" is given off; the liquid has the appearance of water, and sufficient may easily be obtained to ascertain whether it is water. The presence of hydrogen in organic substances is thus discovered; its origin from water may now be explained, and the double function of water in the plant and animal economy may be referred to—viz. that it both enters into the composition of the animal and plant structure and also acts as a solvent. The combustion of ordinary coal gas, of alcohol, of petroleum, of oil and of candles, may then be

[1] The importance of drying the gas is realized without difficulty, as previous observations have shown that the air is moist, and as the gas is given off in presence of water, lime may be used.

studied, and the presence of hydrogen in all of these noted.

PROBLEM XI. *To determine whether oxides such as water and chalk gas may be deprived of oxygen by means of metals.*—It being found that hydrogen and carbon withdraw the oxygen from some but not from all metals, it follows that some metals have a stronger, others a weaker, hold upon or "affinity" to oxygen than has either hydrogen or carbon; the question arises whether any and which metals have so much greater an affinity to oxygen that they will withdraw it from hydrogen and carbon. Copper and iron have been found to part with oxygen, but zinc and magnesium did not, so these four metals may be studied comparatively. Steam is passed through a red-hot copper tube full of copper tacks: no change is observed. The experiment is repeated with an iron tube charged with bright iron nails: a gas is obtained which is soon recognized to be hydrogen, and on emptying out the nails they are found to be coated with black scale. Zinc and then magnesium are tried, and, like iron, are found to liberate hydrogen. Chalk gas is next passed over red-hot copper, and is found to remain unchanged, but on passing it over red-hot iron or zinc a gas is obtained which burns with a clear blue smokeless flame: this gas is not absorbed by milk of lime, but on combustion yields chalk gas, so it evidently contains carbon, and is a new combustible gas. Like hydrogen, it is found to afford an explosive mixture with oxygen. Finally, magnesium is heated in chalk gas: it is observed to burn, and the magnesium to become converted into a blackish substance unlike the white oxide formed on burning it in air. But it is to be expected that this oxide is produced, and to remove it, as it is known from previous experiments to be soluble in muriatic acid, this acid is added: a black residue is obtained. What is this? Is it not probable that it is carbon? If so, it will burn in oxygen yielding chalk gas. So the experiment is made. These experiments in which hydrogen is obtained from water and carbon from chalk gas afford the most complete "analytic" proof of the correctness of the conclusions previously arrived at regarding water and chalk gas, and which were based on "synthetic" evidence; taken together, they illustrate very clearly the two methods by which chemists determine composition.

As hydrogen and carbon form oxides from which oxygen may be removed by means of some metals but not by all, the question arises, Which has the greater hold upon or affinity to oxygen—carbon or hydrogen? As it is the easiest experiment to perform, steam is passed over red-hot charcoal: a combustible gas is obtained which yields water and chalk gas when burnt, so evidently the hydrogen is deprived of its oxygen, and this latter combines with the carbon, forming the combustible oxide of carbon. Will not carbon partly deprive chalk gas of its oxygen? The experiment is made and it is found that it will. These results afford an opportunity of calling attention to and explaining the changes which go on in ordinary fires and in a furnace.

PROBLEM XII. *To determine the composition of salt gas, and the manner in which it acts on metals and oxides.*—It has previously been demonstrated that spirits of salt or muriatic acid is prepared by acting on salt with oil of vitriol and passing the gas which is given off into water; the solution has been found capable of dissolving various metals and oxides, chalk, lime, &c., and as water alone does not dissolve these substances the effect is apparently attributable to the dissolved gas, so it becomes of interest to learn more of this gas in order that its action may be understood. It is first prepared; its extreme solubility in water is observed, and also the fact that as it dissolves much heat is given out; and it is noted that although colourless and transparent it fumes in the air. How is its composition to be determined? Is there any clue which can be followed up? Reference is made to the previous observations, and it is noted that its solution dissolves various metals with evolution of hydrogen; water alone has no such effect. Is this hydrogen derived from the water or from the dissolved gas? The gas alone is passed over heated iron turnings, and the escaping gas is collected over water: it proves to be hydrogen, so evidently salt gas is a compound of hydrogen with something else. How is this something else to be separated from the hydrogen? Do not previous experiments suggest a method? Yes, they have proved that hydrogen has a marked affinity to oxygen, and now it is recollected that on treating muriatic acid with red lead—a substance rich in oxygen—a greenish-yellow gas is obtained. The experiment is repeated on a larger scale and the gas is examined. If it is contained together with hydrogen in salt gas, perhaps salt gas will be obtained on applying a flame to a mixture of the two gases just as water is from a mixture of oxygen and hydrogen: the mixture is made and fired, and the result leaves little doubt that salt gas does consist of hydrogen in combination with the greenish-yellow gas—chlorine. Whence is this chlorine derived—from the salt or the sulphuric acid?

The notes are again consulted, and it is seen that a solution of silver in nitric acid gave a characteristic precipitate with muriatic acid but not with sulphuric, so salt solution is added to the silver solution, and a precisely similar precipitate is obtained, leaving little doubt that the chlorine is derived from the salt. It is now easily realized that the iron and zinc displace the hydrogen of the dissolved hydrogen chloride. What happens when the oxides are acted on? In addition to the metal they contain oxygen, which is known to combine readily with hydrogen, forming water; is water formed? Lime oxide is therefore heated in hydrogen chloride; a liquid is obtained which behaves exactly as a solution of hydrogen chloride in water. When the action is complete, after driving off all that is volatile, a solid remains very like fused common salt—doubtless zinc chloride, as it is to be supposed that as the hydrogen has taken the place of the zinc the chlorine has taken the place of the oxygen. What, then, is the action of hydrogen chloride on chalk? It evidently not only separates the chalk gas from the lime, but also dissolves this latter. What is formed? Dry (unslaked) lime is therefore heated in a current of hydrogen chloride. It behaves just as zinc oxide, yielding a liquid product—evidently a solution of hydrogen chloride in water, as it dissolves zinc with evolution of hydrogen, and the residue is like that of zinc chloride. The important discovery is thus made that lime also is an oxide—that chalk, in fact, is a compound of two oxides; the resemblance of lime to zinc oxide and magnesium oxide is so striking that the conclusion is almost self-evident that lime is probably a metallic oxide, and it may be here pointed out that this actually is the case. The gradual discovery of the composition of chalk in the manner indicated is an especially valuable illustration of chemical method, and serves to show how chemists are often obliged to pause in their discoveries and to await the discovery of new facts and methods of attack before they are able to completely solve many of the problems which are submitted to them. The solids obtained on dissolving zinc oxide and lime in muriatic acid and boiling down the solution, when all the water is driven off, are white solids like fused salt, but on exposure they gradually become liquid. In so doing they increase in weight, and evidently behave like sulphuric acid. Probably water is absorbed from the air: no change takes place when they are kept over sulphuric acid or dry lime. In this way two new desiccating agents are incidentally discovered.

PROBLEM XIII. *To determine the composition of washing-soda.*—The study of this substance is of importance as introducing the conception of an alkali. The preparation from salt is first described. On heating the crystals they melt and give off "steam"; the experiment is made in such a way that a quantity of the liquid is obtained sufficient to place beyond doubt that it is water. The water is found to be easily driven off on heating the crystals in the oven, and to constitute a very large proportion of the weight of the crystals. The conception of water of crystallization is thus gained. On heating the dried substance to full redness in the platinum dish, no loss occurs. The residue dissolves in water, and "soda crystals" may again be obtained from the solution, so that heat does not affect it. Perhaps acids which have been found to act so powerfully in other cases will afford some clue. On trial this is found to be the case: a colourless, odourless gas is given off, which extinguishes a burning taper. Is this perhaps nitrogen or chalk gas? The lime water test at once decides that it is the latter. So it is determined that washing-soda, like chalk, is a compound of chalk gas—but with what? With an oxide? The dried substance is heated in hydrogen chloride: chalk gas is given off as before, and a liquid which is soon recognized as water saturated with hydrogen chloride. The residue dissolves in water, and separates from the concentrated solution in crystals exactly like salt, and, in fact, is soon recognized to be salt; evidently, therefore, that which is present in salt along with chlorine is present in soda crystals along with oxygen, chalk gas, and water. The preparation of the metal sodium from soda is then explained. Acquaintance being thus made with compounds of chalk gas with two different oxides, the question arises, which oxide has the greater affinity to the chalk gas? Will lime displace sodium oxide from soda or *vice versâ?* On adding lime water to soda solution, a precipitate of chalk is formed. What does the solution contain? Lime water contains lime in combination with water; is the sodium oxide present in combination with water? Soda is boiled with milk of lime (in an iron saucepan to avoid breakage) until it no longer affects lime water; afterwards the liquid is poured off and boiled down. The product is very unlike soda: it is very caustic, and when exposed to the air becomes liquid. If it is an analogous substance to slaked lime, it should combine with chalk gas and be reconverted into soda; this is found to be the case. Caustic soda is thus discovered. Chalk and lime are known to neutralize acids; both soda and caustic soda are found to do so, and their effect on vegetable colours is found to be the reverse of that of acids. At this stage the origin of the name alkali is explained, and it is pointed out that the oxides which have been studied may be arranged in two groups of alkali-like or *alkylic* and acid-forming or *acidic* oxides, the former being derived from metals, the latter from non-metals. The production of *salts* by the union of an oxide of the one class with the oxide of the other class is then illustrated by reference to earlier experiments.

The point is now reached at which the results thus far obtained may be reconsidered. The student has been led in many cases to make discoveries precisely in the manner in which they were originally made; and it is desirable that at this stage, if not earlier, the history of the discovery of the composition of air and water, &c., should be briefly recited. It is then pointed out that a variety of substances have been analyzed and resolved into simpler substances—air into oxygen and nitrogen, water into oxygen and hydrogen, &c.; and that these simpler substances thus far have resisted all attempts to further simplify them, and are hence regarded as elements. A list of the known elements having been given, the diverse properties of the elements may be illustrated from the knowledge gained in the course of the experiments. The fact that when elements combine compounds altogether different in properties from the constituents are formed also meets with manifold illustration. Too little has been ascertained to admit of any general conclusion being arrived at with regard to the proportions in which elements combine, but it is clear that they may combine in more than one proportion since two oxides of carbon have been discovered, and in the only cases studied—viz. copper oxide and chalk—the composition has been found not to vary. The existence of various types of compounds has been recognized, and a good deal has been learnt with reference to the nature of chemical change. But, above all, the method of arriving at a knowledge of facts has been illustrated time after time in such a manner as to influence in a most important degree the habit of mind of the careful student. New facts have been discovered by the logical application of previously discovered facts: the logical use of facts, and the habit of using facts have been inculcated. This is all-important. It has become so customary to teach the facts without teaching how they have been discovered that the great majority of chemical students never truly learn the use of facts; they consequently pursue their daily avocations in a perfunctory manner, and only in exceptional cases manifest those qualities which are required of the investigator; their enthusiasm is not awakened, and they have little desire or inclination to add to the stock of facts. It must not for one moment be supposed that the object of teaching chemistry in schools is to make all chemists. Habits of regulated inquisitiveness, such as must gradually be acquired by all who intelligently follow a course such as has been sketched out, are, however, of value in every walk of life; and certainly the desire to understand all that comes under observation should as far as possible be implanted in everyone.

STAGE V.—*The quantitative stage.*

The *quantitative* composition of many of the substances which have previously been studied qualitatively should now be determined—in some cases by the teacher in face of the pupils, so that every detail may be observed and all the results recorded; in other cases by the pupils.

The composition of water is first determined by Dumas' method; this may easily be done, and fairly accurate results may be obtained in the course of a couple of hours. The results obtained by Dumas and subsequent workers should then all be cited, and, attention having been drawn to the extent to which such experiments are necessarily subject to error, the evidence which the results afford that hydrogen and oxygen combine in certain *fixed and invariable proportions* to form water is especially insisted upon.

The composition of chalk gas is next determined; this also is easily done, as impure carbon (lampblack) may be burnt and the hydrogen allowed for. Again, attention is directed to the results obtained by skilled workers, and the evidence which they afford that chalk gas never varies in composition.

The composition of copper oxide has already been ascertained; it may be re-determined by reducing the oxide in hydrogen: in fact, in determining the composition of water.

The lead oxides may be reduced in a similar manner, the oxide obtained by igniting white lead as well as red lead and the brown oxide obtained by treating red lead with nitric acid being used. In this way it is ascertained that the brown oxide is the highest oxide; the loss in weight which this oxide suffers when ignited may then be determined.

Tabulating the results thus obtained, after calculating with what amount of the particular element that quantity of oxygen is associated which in water is combined with one part by weight (*unit weight*) of hydrogen, numbers such as the following are obtained:—

1 part of hydrogen is combined with 8 parts of oxygen in water.

3 parts of carbon are combined with 8 parts of oxygen in chalk gas.

31·5 parts of copper are combined with 8 parts of oxygen in copper oxide.

103·5 parts of lead is combined with 8 parts of oxygen in lead oxide (litharge).

51·8 parts of lead are combined with 8 parts of oxygen in lead oxide (brown).

These clearly illustrate the fact that elements combine in very different proportions, and the results obtained with the lead oxides afford also an illustration of combination in multiple proportion.

The amounts of silver and lead nitrates formed on dissolving silver and lead in nitric acid are next determined by evaporating the solutions of known weights of the metals in porcelain crucibles on the water-bath, and then drying until the weight is constant; accurate results may be easily obtained, and these two exercises afford most valuable training. The nitrates are subsequently evaporated with muriatic acid and the weights of the products determined. What are these products? Does the metal simply take the place of the hydrogen in hydrogen chloride as zinc does when it dissolves in muriatic acid? If so, the products are silver and lead chlorides, and it may be expected that the same substances will be obtained—that the same increase in weight will be observed, when, say, silver is combined directly with chlorine as when it is dissolved in nitric acid and the solution is precipitated with muriatic acid or salt. Silver is, therefore, heated in chlorine, and is found to increase in weight to the same extent as when it is dissolved in nitric acid, &c.; a given weight of silver precipitated by salt is also found to increase to the same extent as when it is directly combined with chlorine. The composition of silver chloride having thus been ascertained, the amount of chlorine in salt is determined. The composition of salt being ascertained, purified dried washing-soda is converted into salt, and also the amount of chalk gas which it contains is determined: from the data, the composition of sodium oxide may be calculated. In like manner the composition of lime may be ascertained by converting chalk into chloride by igniting it in hydrogen chloride, and then determining the chlorine in the chloride; the same method may be applied to the determination of the composition of the oxides and chlorides of zinc, magnesium, and copper.

Discussing these various results, and comparing the quantities of oxygen and of chlorine which combine with any one of the metals examined, it is seen that in every case about 35·4 parts of chlorine take the place of 8 parts of oxygen. Combination in *reciprocal proportions* is thus illustrated, and by considering the composition of chalk and washing-soda it may be shown that this applies equally to compounds of two and to compounds of three elements. As 35·4 parts of chlorine are found in every case to correspond to 8 parts of oxygen, it is to be expected that hydrogen chloride contains one part of hydrogen in combination with 35·4 parts of chlorine; a solution containing a known weight of hydrogen chloride is, therefore, prepared by passing the gas into a tared flask containing water and the chlorine is then determined.

It being thus clearly established what are *equivalent* weights of elements, the conception of equivalents may be further developed by exercises in acidimetry carried out by the pupils themselves. The proportions in which washing-soda and hydrogen chloride interact may be determined by mixing solutions of known strength until neutralization is effected; if the solution be evaporated and the chloride weighed, the results may be used in calculating the composition of hydrogen chloride; they serve, in fact, as a check on the conclusions previously arrived at as to the composition of washing-soda and hydrogen chloride. Solutions of sulphuric and nitric acid may be similarly neutralized, and, the amounts of sulphate and nitrate formed having been ascertained, the equivalents of the acids may be calculated on the assumption that the action is of the same kind as takes place in the case of hydrogen chloride. Determinations of the strengths of acids, &c., may then be made. In a similar manner the volumetric estimation of silver may be taught, and the percentage of silver in coinage and other alloys determined.

Such a series of quantitative exercises as the foregoing, when carried out *before* and to a considerable extent *by* the pupils, undoubtedly affords mental discipline of the very highest order, and is effective of good in so many ways that the value of such teaching cannot be over-estimated. The failure to grasp quantitative relationships which examiners have so frequently to deplore is without question largely, if not alone, due to students' entire ignorance of the manner in which such relationships have been determined. Moreover, the appreciation by the general public of the principles on which quantitative analysis is founded would undoubtedly be directly productive of good in a multiplicity of cases.

STAGE VI.—*Studies of the physical properties of gases in comparison with those of liquids and solids. The molecular and atomic theories and their application.*

A series of quantitative experiments on the effect of heat on solids, liquids, and gases should now be made, and these should be followed by similar experiments on the effect of pressure; the similar behaviour of gases, and the dissimilar behaviour of liquids and solids, is thus made clear. The condensation of gases is then demonstrated and explained, and also the conversion of solids and liquids into gases, and the dependence of boiling-point on pressure and temperature. Regnault's method of determining gaseous densities is studied, and the method of determining vapour densities is illustrated. The molecular constitution of a gas is now discussed; the phenomena of gaseous and liquid diffusion are studied, and a brief reference is made to the kinetic theory of gases; then Avogadro's theorem is expounded and applied to the determination of molecular weights; and eventually the atomic theory is explained, and the manner in which atomic weights are ascertained is brought home to the pupils. The use of symbols must then be taught. Finally, the classification of the elements in accordance with the periodic law should be explained.

It is all-important that at least a large proportion of the experiments in each of the stages should be made by the pupils; but even if this were not done, and the lessons took the form of demonstrations, much valuable instruction might still be given.

The majority of pupils probably would not proceed to the fifth and sixth stages; but those who perforce must terminate their studies without gaining any knowledge of chemical philosophy should unfailingly be led to make a few simple quantitative experiments: for example, to determine silver volumetrically, and the method of determining the composition of water and chalk gas should be demonstrated in their presence: and it may be added that, if only the examples in Stages I. and II. and Problems I. to V. of Stage III. were thoroughly worked out, most important educational training would be given, and much valuable information as to the nature of common phenomena would be gained.

The complete course would undoubtedly take up considerable time, but so does a satisfactory mathematical or classical course of study, and it is absurd to suppose that useful training in science is to be imparted in a few months. If instruction be given in the manner suggested at all generally, it will be necessary, however, to modify the present system of testing results. Pupils could not be expected to pass at an early age examinations such as are at present held, and awards would have to be based chiefly on an inspection of the classes at work and of note-books and on *vivâ voce* questioning. But all are agreed that the present system of payment on results tested by a terminal examination is a most unhealthy one, and that a more rational system *must* be substituted for it. I may suggest that if members of the staff of science colleges, such as are now established in so many towns, could be appointed *supervising inspectors*, whose duty it would be to advise teachers in schools and *occasionally* to inspect the teaching in company with the permanent inspector, it would be possible to secure the assistance of a body of men who are in touch with scientific progress and conversant with the improvements which are being effected. A man who "once an inspector is always an inspector" of necessity must get into a rut, and will escape from the wholesome leavening and rousing influence which is always more or less felt by those whose office it is to follow the march of scientific progress.

It should also here be pointed out that the great majority of the experiments and exercises described may be carried out with very simple apparatus, and with slight provision in the way of special laboratory accommodation. In but very few cases is there any production of unpleasant smells or noxious fumes. It is, in fact, a mistake to suppose that an elaborately fitted laboratory is in every case essential for successful teaching: much might be done in an ordinary schoolroom provided with a demonstration bench for the use of the teacher, a draught closet over the fire-place, a sink, a raised table for balances (raised so that the teacher might see what was going on), a cupboard for apparatus, and a long narrow bench provided with gas-burners at which, say, twenty pupils might stand, ten a-side. At present the Science and Art Department will not recognize "practical chemistry" unless it be taught in a laboratory fitted up in a certain specified manner, and their regulations are such as to enforce the provision of expensive laboratories in all cases where it is desired to obtain the grant. If greater latitude in fittings were allowed, more attention being paid to the character of the work done and less to the tools with which it is accomplished, probably much less money would be wasted by inexperienced school authorities in providing special laboratories, and there would be much greater readiness displayed to enter on the teaching of experimental science. The course which has been sketched out is one which doubtless might well be modified in a variety of ways according to circumstances. Thus many simple exercises in mechanics, in addition to those directly mentioned, might be introduced into Stage II., and the mechanical properties of common materials might be somewhat fully studied at this stage in districts where engineering trades are largely established, and where such knowledge would be specially valuable. In like manner the physical effects of heat on substsnces might be studied in Stage III. instead of Stage VI. And there are other chemical problems and simple exercises besides those described which might be substituted for some of them, or included in the course.

Probably, however, it would be found undesirable, if not impossible, as a rule, to continue the teaching of chemistry proper much, if at all, beyond the stage indicated in this scheme. Other subjects will have a prior claim should it ever be deemed essential to include in a comprehensive scheme of school education the elements of the chief physical and physiological sciences; it certainly is of primary importance to introduce at as early a period as possible the conception of energy, and to explain the mechanical theory of heat, so that later on it may be possible to discuss the efficiency of heat and other engines; and, until the laws of the electric current are understood, the subject of chemical change can never be properly considered.

In many cases, where it is convenient or desirable to continue the chemical studies, it probably will be advantageous as a rule that they have reference to specific (local) requirements—*e.g.* to agriculture in schools in agricultural districts; to food materials and physiology in the case of girls especially, &c. But in any case more consideration must be paid in the future in schools where chemistry is taught to educational requirements—the teaching must have reference to the requirements of the general public; and it must be remembered that the college, not the school, is the place for the complete study of a subject.

With the object of presenting in an available form information as to the position occupied by chemistry in Board and other public elementary schools, which are controlled either by the Education Department, Whitehall, or the Science and Art Department, South Kensington, the Committee now present a report on the subject which has been prepared by Prof. Smithells. A consideration of this statement will show that, as in the higher grade public schools, with which the Report of the Committee last year was chiefly concerned, the condition of the teaching in public elementary schools is far from satisfactory. As a rule chemistry is not taught on the proper lines. The pupils frequently receive the same kind of instruction in chemistry as they would at a later stage if they were preparing for a professional or technical career; consequently the subject has failed to provide that mental education which it should be the main object of elementary teaching to develop. It appears, too, that in many of these schools physical science has not hitherto been regarded as a necessary part of the educational scheme. It is essential that this state of affairs should be altered, and that physical science should occupy a more favourable position in the Education Code, and that its teaching should be more thoroughly controlled.

It is to be hoped also that the Education Department, as well at the Science and Art Department, South Kensington, will take steps to arrange a more efficient mode of inspecting science teaching than that at present in vogue, which can only be regarded as satisfactory from a purely statistical standpoint. Under the present system little or no control can be exercised over the science teaching, since the Whitehall inspectors are, as a rule, not qualified to form an opinion as to its value. There would seem to be no difficulty in obtaining the services of properly qualified persons to act as additional inspectors for the purpose of reporting on the character of the science teaching. It is probable that many of the professors and lecturers in University Colleges, and other educational institutions, might be willing to take part in such inspection, and it would thus become possible to maintain a high standard of excellence in the teaching.

THE GEOLOGICAL PAPERS AT THE BRITISH ASSOCIATION.

ON Thursday morning the first business of Section C was to hear Prof. Milne's ninth Report on the earthquake and volcanic phenomena of Japan, in which a list of seventy-nine earthquakes occurring between June 1888 and March 1889 is given. After a paper by Dr. Naumann, which will be referred to later on, Mr. T. P. Barkas read a paper on footprints of four-, three-, and two-toed animals, discovered in Lower Carboniferous sandstones near Otterburn, of which he exhibited specimens. A paper by Mr. Mellard Reade reviewed the chief theories advanced to account for the Lower Triassic rocks, and advocates their formation by tidal action in straits, seas, and bays from the denudation of the rocks of the Channel, Mendips, Belgian coal-field, Pennine, and the Old Red of Herefordshire.

Friday's sitting opened with Dr. A. Geikie's paper on the age and origin of the crystalline schists of Norway. In the Trondhjem region ordinary sedimentary rocks, much disturbed, contain Lower and Upper Silurian fossils, and are underlain by basic lavas and tuffs, succeeded by grits, slates, and schists with black pyritous and carbonaceous beds. Traced southwards, the whole series becomes progressively more crumpled and crystalline until it passes into a group of twisted mica schists, in which, however, the pyritous shales, although converted into mica schists, are still recognizable. Specimens were exhibited to show every step of metamorphism from an amorphous igneous rock to a perfect schist, the change being sometimes visible in a hand specimen In Bergen the author confirmed the discovery of fossils by Dr. Reusch in a frilled mica schist or phyllite, proving that the regonial metamorphism in this area was of post-Silurian date. Mr. Marr followed with a description of the Skiddaw slates on the east side of Brownber, where quartz veins have been intruded between the bedding planes, the rock has been contorted, and converted into a rock composed largely of mica and secondary quartz, and exhibiting *ausweichungsclivage*, in fact a mica schist. Prof. Bonney contributed a paper showing that the limestones associated with crystalline rocks were coarsely crystalline as a rule, but that pressure often obliterated this coarse texture by crushing, and thus could only be appealed to as a minor agent in producing crystallization; a further paper by the same author dealt with the fossils obtained amongst the crystalline schists in the Val Canaria, Val Piora, Nufenen Pass, and Lukmanier Pass; he concluded that in the first two localities the relations of the rocks had been misunderstood, while in the last two the fossils were in a rock whose minerals were in a very different state from those in the older crystalline schists. Mr. Watts exhibited a collection of Belemnites from the rocks of the Lukmanier Pass. Dr. Hatch described potash and soda felsites from the Lower Silurian of Ireland, which were ancient equivalents of the rhyolites and pantellerites of to-day; and Mr. A. R. Hunt brought forward a view that the granites of Dartmoor and of the Channel were of pre-Devonian and probably Archæan age. Mr. Teall sent an interesting communication on the amygdaloids of the Tynemouth dyke, in which he summarized the history of the rock as follows: (1) development of granular aggregates of felspar allied to anorthite under plutonic conditions; (2) addition of new felspar substance to these, giving them outward crystalline form; (3) formation of lath-shaped felspars; (4) separation of augite; (5) formation of vesicles probably due to relief of pressure when the magma rose into a fissure; (6) filling of some of these vesicles with interstitial matter which probably oozed into them from the surrounding liquid magma, as they are seen in all stages of filling; (7) consolidation of interstitial matter; (8) filling up of the rest of the vesicles with carbonates. Mr. Swan exhibited specimens of marble from Paros, and described the new and old quarries; and then the Section listened to an account from Dr. Fridtjof Nansen of the geological bearings of his journey across Greenland.

Greenland is covered by a shield of ice rising to a height of 9000 or 10,000 feet in the centre, where it probably covers an area of mountains and valleys, and not a table-land, reduced to a gently sloping surface, and even polished, by the wind. The only evidence of ice melting on the surface in the interior consists of thin ice crusts at varying depths. The enormous pressure of the ice mass forces it out partly as ice and partly as water melted by friction, thus giving rise to the rivers, which flow even in winter. The great rate at which the ice flows out into the fjords makes the author an advocate for the agency of ice in forming these features.

On Saturday, Prof. W. C. Williamson read a paper in which he acknowledged the help he had received from all parts of the world in acquiring specimens and slides of coal and mineral charcoal from many English, Welsh, and Scotch localities, as well as from Japan, New Zealand, America, Europe, Asia, and Australia. The inquiry was still proceeding, with a view to ascertain the nature and origin of this mineral charcoal, and to estimate the extent to which cryptogamic spores contributed to coal formation. Prof. Williamson further stated that in *Lyginodendron Oldhamium*, he added a fern to the other cryptogams in which exogenous growth took place, and announced what he termed another botanical heresy, that in the Carboniferous Lycopods the vascular bundle enlarged into a ring inclosing a medulla which enlarged *pari passu* with the ring. Prof. T. R. Jones reviewed the advancement made by himself and others to our knowledge of the Palæozoic Phyllopoda; and Dr. Johnston-Lavis's Report on Vesuvius was presented. This Report announces that Messrs. Philip and Son will shortly publish the map of Vesuvius; it further gives a diagram of the cone in 1887 and 1886 (? 1888), and three taken in January, May, and August, 1889, so as to show the changes resultant on overflows of lava, formation of fissures, and building of new cones. The Report concludes with a further account of the new railway tunnels in the Phlegræan Fields.

Further specimens of the peculiar coral-like structures from the limestone of Culdaff have been obtained by the Geological Survey, and some of these, with photographs, were exhibited to the Section by Prof. Hull. Some foreign palæontologists, judging from the photographs, regarded them as organic, and referred them to Favistella, but English palæontologists give only a hesitating assent to this view. Mr. Cameron described Kellaway's sand and doggers from exposures near Bedford, and Mr. Vine described sixteen species of Stomatopora and Proboscina from the Hunstanton Red Chalk.

On Monday, Mr. Ussher's paper on the Devonian rocks of Britain was presented. He divided the rocks into three typical areas, in each of which they presented peculiar characters. In North Devon there are arenaceous deposits indicating shoal water; in South Devon the rocks are variable, with sporadic volcanic and coral deposits; while in Cornwall and Devon, west of Dartmoor, the succession, though much disturbed and faulted, consists chiefly of mud and slates. A table is given, correlating the principal divisions in these three areas with their Franco-Belgian and German equivalents. An important paper by Prof. Lebour and Mr. Marley, on the South Durham salt industry and the extension of the Durham coal-field, followed. The area of proved salt amounted to at least twenty square miles, and although it had been found not to extend to Seaton Carew, there was no doubt that the eastern and northern borings at South Bank and North Ormesby did not mark the limits of the salt in those directions. The thin coals found in the Seaton boring were regarded by Prof. Lebour as being of gannister or millstone-grit age, and hence of little value except in giving an idea of the structure of the Carboniferous rocks below their red-rock covering. Mr. De Rance's Underground-water Report gave the details of some of these borings, as well as others from Devon, Worcester, Leicester, Lincoln, Lancashire, Hertfordshire, and the south of England. Dr. Embleton contributed a description of *Loxomma Allmanii* from the Northumberland coal-field; Dr. Traquair, of Devonian fishes from Scanmenac Bay and Campbellton, in Canada; and Mr. Smith Woodward, of *Onychodus* from Spitzbergen, and of six new species and two new genera of Liassic fishes. Dr. R. Laing read a paper on a Neolithic interment in Robin Hood Cave, and on the discovery of *Felis brevirostris* in a Pleistocene deposit in the same cavern.

The Section then joined with Section A to hear a joint paper by Profs. Thorpe and Rücker, on the relation between the geological constitution and magnetic state of the British Isles. In this the authors recorded that the magnetic elements had been determined at 200 stations in the United Kingdom, with the result that the declination was found to be subject to local or regional disturbing causes centred in a comparatively small number of spots or lines distributed in various parts of England. The regions mentioned are: (1) the fault-line of the Caledonian Canal; (2) the basalt of the Inner Hebrides; (3) the coal-field of South Scotland; (4) the region of South-East Yorkshire, where the Jurassic rocks are thin; (5) the basalt of Mid-Wales and Shropshire; (6) the line of the "London Palæozoic Ridge"; (7) the basalt of Antrim; (8) the igneous rocks of Connemara. All the principal masses of basalt, and those spots where geologists know or suspect the older rocks to be near the surface, form centres or lines of attraction. As the result of this and of the following reasons, the authors are strongly of opinion that the disturbance is due, not to earth-currents, but to local magnetic rocks, such as basalt, or others like the Malvern diorite, which, though not strongly magnetic in the laboratory, produces a deviation of 20′ of arc even at a distance of a mile from the axis. Only small earth-currents, or none, were detected at such places as Melton Mowbray; and near Reading and Windsor, where the disturbance was great, the earth-currents must circulate *round* the disturbed districts in a manner for which it would be difficult to find an adequate physical cause, while, if the currents are deep-seated, it is not easy to understand the extreme localization of their action. In connection with this paper we may note the exhibition, by Prof. Hull, of a piece of magnetically polar diorite, and a paper by Dr. Edward Naumann, in which he advocated a magnetic survey of the globe, and brought forward a set of results from Japan and elsewhere to show the dependence of magnetic lines on lines of fault, fissure, and elevation. He, however, attributed the magnetic disturbance to the deflection of earth-currents by the great lines of fissure and tectonic disturbance.

Tuesday was chiefly devoted to Pleistocene papers, opened by Dr. Crosskey, who exhibited a large map showing the distribution of Welsh, Lake Country, Scotch, and local erratics. His report described erratics reported by the Yorkshire Boulder Committee and by Mr. Bucknill in Lancashire, and drew attention to (1) the grouping of erratics from special localities; (2) the occasional mingling of groups; (3) the occurrence of high and low level erratics; and (4) the distribution of trails of the latter in accordance with existing physical features. Mr. Whitaker described a deep and steep-sided channel filled with drift in the Cam Valley; Mr. Lamplugh, a new locality for the Arctic shell bed in the boulder clay on Flamborough Head; and Mr. Howorth contributed two papers on which there was considerable discussion. In the first he combated the theory of an ice-cap, on the grounds that many northern lands had no drift, that the southern glaciation was contemporaneous and not alternate with the northern and that in New Zealand and Australia there is nothing corresponding to the drift phenomena of the northern hemisphere, that there is little or no evidence of other earlier glacial periods, that palæontological evidence is against such a theory, and that the advance of ice-sheets over hundreds of miles of plain without any *vis a tergo* is a physical impossibility; in the second, after showing that there is evidence of a connection in Pleistocene times between Siberia and America, not by way of Japan, but probably through the shallow Arctic seas to the north, he considers that the necessary elevation of 25 or 30 fathoms would make the great Siberian rivers flow southward, and terminate in an inland sea stretching east from the Caspian, just as the principal rivers of Russia (Siberia in Europe) now flow into the Black Sea and Caspian. In the discussion it was, however, pointed out that many of the rivers flowed far too rapidly to have their directions thus reversed.

Among the other papers were: one by Prof. Haddon, describing the volcanic and coral deposits of the islands in Torres Straits, where no proof of elevation or of subsidence was to be obtained; one by Mr. Dorsey, on the Witwatersrande Gold-fields; a Report by Mr. Bell, on the manure gravels of Wexford; and one by Dr. F. Clowes, describing rocks at Bramcote and Stapleford cemented by barium sulphate, and the occurrence of the same substance deposited in pipes and water-boxes connected with the pumps of Durham collieries.

On Saturday Mr. Starkie Gardner's report on the Osborne and Bembridge floras of the Isle of Wight and the correlation of the Bovey beds with beds of about Bracklesham age was read, followed by a short paper of Prof. Green's on the concretionary nodules formed by molecular rearrangement into radial crystalline groups of the tufaceous deposits of the magnesian limestone. Mr. Topley next gave an admirable *résumé* of the work of the Geological Survey in Northumberland and Durham, which have been mapped on the 6-inch scale, and published in two sets of "drift maps" and "solid maps" on the 1-inch. He noted the whole sedimentary series from the Silurian to the Trias, the glacial beds, and the numerous intrusive and interbedded igneous rocks. The last paper was an extremely interesting one by Mr. R. H. Tiddeman on concurrent faulting and deposit in Carboniferous times. The author describes three branches of the Craven group of faults, and then shows that there are vast differences between the quality of the Pendleside grits and Bowland shales on one side of the fault and the corresponding Yoredale series on the other, while the 5500 feet of Carboniferous limestone on the north side of the faults is in strong contrast to the 800 feet on the other side, suggesting great differences in the conditions of deposit. As the faults form the boundary between the two types of rocks, as there is no trace of transition there, and as the thickest beds are on the down-throw side, the author suggests that faulting must have gone on contemporaneously with the deposit. A note was appended describing knolls of crystalline limestone full of fossils and bordered by limestone breccias, which were regarded as reefs growing in the Carboniferous ocean.

Reviewing this list of papers, it is obvious that, though many of them were not of a class to interest the somewhat popular audience which listened to them, there are a large number of great scientific interest which mark a very considerable advance made in our knowledge during the past year.

THE BIOLOGICAL PAPERS AT THE BRITISH ASSOCIATION.

As has been the custom for the last few years, a good deal of time was devoted to the discussion of topics of general biological interest. The subjects selected for these discussions were, "The Transmission of Acquired Characters" and "The Utility of Specific Characters," which were respectively opened by Mr. E. B. Poulton, F.R.S., and Prof. Romanes, F.R.S. There were also an extremely large number of botanical and zoological papers, but no physiological papers, owing to the absence of most of the physiologists, who were attending the Physiological Congress at Basle. In the following account only a few of these papers are abstracted, as it would be impossible to do justice to all in a limited space.

Mr. Romanes opened a discussion on specific characters as useful and indifferent. The question to be debated was, whether *all* characters were adaptive, and had been brought about by natural selection, or whether there were not specific characters which had no utilitarian significance? The naturalists who hold the former view were apt to beg the question by assuming that, if a given character could not be explained as due to utilitarian principles, it was simply due to a failure to see the need for it; this way of dealing with the question is really unscientific dogmatism. The author had selected certain groups, and tabulated the various specific characters, placing on one side those which were conceivably of advantage, and on the other side those which were apparently useless; the latter were found to preponderate. This was especially clear in the coloration of birds: to take one instance, the breast and abdomen of woodpeckers are variously coloured, and yet these parts of the body are habitually concealed; here it is most difficult to conceive how natural selection can have been the cause of the various modifications. It must, in fact, be admitted that other influences besides natural selection have led to the production of specific characters which are not in any way useful as such. Sexual selection, in the first place, although Mr. Wallace rejects it, must be considered as important. There is an enormous amount of evidence that climate—as we summarize a vast number of external conditions of life—has a uniform and permanent influence upon specific characters. A striking evidence of this influence is seen in the faunas of caves; here we see a loss of coloration and other peculiarities in the most different groups of animals. It has been attempted to explain this change as due to natural selection acting directly upon their physiological constitutions, and so indirectly upon their colours. This explanation would be reasonable if only one class of animals were concerned; but to assume that representatives of the most diverse classes of animals are acted upon in an identical fashion by natural selection is to assume too much; the changes must be due to the direct influence of the environment. Weismann's use of "panmixia," or negative natural selection, to account for such changes, fails, inasmuch as it should also follow that the fauna of the deep sea, which is exposed to identical conditions as regards darkness, and even temperature, should show an absence of coloration; but it is notorious that the reverse is the case. Again, the rabbits of the island of Porto Santo, near Madeira, which are the progeny of a few pairs introduced in the fifteenth century, differ in certain peculiarities of coloration which cannot be regarded as adaptive: in so short a time as four years some of these rabbits, when brought to England, reverted to the original type; this seems to be the clearest case of the direct influence of climate. Food is known to have a direct influence on coloration, but as yet there is not very much definitely known about these influences; for instance, the bullfinch turns black when fed upon hempseed, and other birds change their colour when fed with cayenne pepper; there can be no doubt that various substances exist in nature which have a similar direct effect upon the plumage of birds which feed upon them. Isolation is another cause of non-beneficial change. So much, then, for specific characters. If the theory of natural selection is good as a theory of the origin of species, it must likewise be good as a theory of the origin of genera; and if specific characters must necessarily all be "useful," so must generic characters. If the doctrine of utility as universal be conceded to fail as regards genera and all the higher taxonomic divisions, it appears inconsistent to maintain that it must necessarily hold as regards species: it is not supposed to hold as regards varieties. This seems to be a most illogical position.

In a paper on the antherozoids of Cryptogams, by Mr. Alfred W. Bennett, the object of the author was to bring out the difference between the two modes in which the ciliated fertilizing organs of Cryptogams are formed, the first type being that which occurs in Vascular Cryptogams, Muscineæ, and Characeæ, the second in Algæ (excluding Characeæ). The essential character of the first type is that the antherozoid is formed from the nucleus only of its mother-cell, the whole of the rest of its protoplasm being consumed in the development of the antherozoid. The vibratile cilia which give to the mature antherozoid its power of rapid movement proceed from a peripheral layer of hyaline protoplasm belonging to the nucleus. In ferns and other vascular cryptogams these cilia are very numerous, forming a tuft attached to the anterior end of the antherozoid. The antherozoids of Muscineæ (Musci and Hepaticæ) and those of Characeæ have only two very long and slender cilia attached in the same position. The structure and mode of development of these organs is almost identical in these two classes. In the Fucaceæ, on the other hand, which may be taken as the highest type of Algæ with ciliated antherozoids, the structure of the antherozoid is altogether different. It is a naked cell, not inclosed in a cellulose-wall, with cytoplasm, nucleus, and pigment-spot; the two cilia both spring from a spot in close proximity to the eye-spot, although one of them is attached to the body of the antherozoid for a portion of its length. The importance of the above facts was pointed out in support of the view that the Characeæ are more nearly related to the Muscineæ than to the true Algæ.

Mr. Poulton read a paper "On the Supposed Transmission of Acquired Characters." The position taken up by Weismann is that acquired characters, *i.e.* characters produced by the incidence of external forces upon the individual body are not in any case inherited. The evidence for such transmission might be direct or indirect; to the former category would belong transmission of mutilations which would be undoubtedly impressed upon the individual body by external influences; the evidence might also be indirect; if it could be shown that evolution was impossible without accepting this principle we should have to accept it. The evidence of transmission of mutilations is not strong, and Prof. Windle has argued very forcibly that monstrosities were due to peculiarities of the ovum and not to external forces. The supposed hereditary effects of use and disuse were unsupported by any proof that the modifications of organs affected by use or disuse had been more complete or more rapid than that of organs not so affected. With regard to instinct, Dr. Romanes had suggested a difficulty—that was, the instinct of certain wasps to sting and paralyze the nerve centres of their prey. But it must be remembered that the benefits arising from this instinct were felt not by the wasps themselves, but by their progeny.

The subject was continued by Mr. Francis Galton, who read a paper entitled, "Feasible Experiments on the Possibility of transmitting Acquired Habits by means of Inheritance," in the course of which he said that feasible experiments have yet to be designed that shall be accepted as crucial tests of the possibility of a parent transmitting a *congenital* aptitude to his children, which he himself possessed, *not congenitally*, but merely through long and distasteful practice under some sort of compulsion. The requirements are to eliminate all possibility of parental or social teaching, to bring up all the descendants in the same way, to make simultaneous experiments on many broods during many generations, and, lastly, to economize time, money, and labour. This list of requirements points with emphasis to experimenting on creatures that are reared from eggs, as fowls, fishes, and moths. *Fowls*.—The largely extending practice of hatching eggs in incubators for commercial purposes, and the varied aptitudes of poultry, make them very suitable subjects. Birds are said to have an instinctive dread of various insects; hence mimetic insects, that are really good for food, are avoided by them. Do such insects exist, and could they be easily reared, which poultry would avoid at first, though experience would soon teach them to like and to eat greedily? Similarly as regards sounds and cries, which would frighten at first, but afterwards be welcomed as signals for food, &c. Would the stocks of two breeders, one of whom adopted such experiments as these and the other did not, differ in instinct after many generations? *Fish*.—The experiment (quoted by Darwin) of Möbius with the pike, using a trough of water divided by a glass plate into two compartments, in one of which was the pike and in the other were minnows, was mentioned as an example. The pike, after dashing at the minnows many times, and each time being checked and hurt by the glass plate, during some weeks, finally abandoned all attempts to seize them, so that when the plate was removed the pike never afterwards ventured to attack the minnows. The question, then, is, whether fish reared for some generations under conditions which compelled them to adopt habits not conformable to their natures would show any corresponding change of instinct. Of course each generation would be reared in a separate tank from its parents. *Moths*.—Experiments have been made for the author by Mr. Frederic Merrifield with *Selenia illustraria*, which has two broods yearly. They are being made for quite another purpose, but have already shown the ease of breeding hardy moths on a large scale when the art of doing so is well understood. All larvæ are fastidious in their diet, but it may well be that certain food which they would not touch at first would after a while be greedily eaten, and be found perfectly wholesome. Experiments on the lines here suggested ought to show the proportion of cases in which acquired aptitudes of several kinds are *certainly not* inherited. They might also, perhaps, show that in a small proportion of cases they *certainly are*. Thus limits would be fixed within which doubt remained permissible. The object of this paper is to invite experts to discuss the details of the most appropriate experiments.

Prof. F. O. Bower read a paper on the meristems of ferns as a study in phylogeny. The author has found as the result of examination of the growing points of root, stem, leaf, and of the sporangium in a considerable number of ferns, that as regards their complexity of structure these plants form a natural series, starting from the filmy ferns, which are the simplest, and proceeding through the Polypodiaceæ and Osmundaceæ to the Marattias: in the latter the whole structure of the meristems, as well as of the mature organs of the sporophyte, is bulky and massive, a character which is well suited to growth in subaërial and dry situations; while in the former the whole structure is relatively delicate, and less complex, and suited rather to a sub-aquatic habitat. A parallel progression from the simpler to the more complex is to be traced also in the prothallus or oophyte of these plants, and the general conclusion is drawn from these observations that the series of the Filicineæ illustrates—perhaps more clearly than any other phylum—the rise of a race of plants from the aquatic to the subaërial habit. Nevertheless they still retain in the mode of fertilization the trace of the aquatic habit, which is only lost in the higher Phanerogamic plants, where the pollen-tube renders unnecessary the presence of fluid water at the moment of fertilization.

The paper by Prof. Hartog, on the structure of *Saprolegnia*, contained an account of the structure of the nucleus and of its division, and also of some remarkable facts concerning fertilization; careful observation showed that nothing whatever passed from the antheridium into the oosphere or the oosporangium during fertilization.

In the paper entitled "Contributions to our Knowledge of the Fresh-water Oligochæta," by Mr. F. E. Beddard, the most important new point was the description of the sexual organs of *Dero*, which have not yet been described; they were stated to agree entirely with those of *Nais*, except that there were no genital setæ.

Mr. Robert Irvine and Dr. G. Sims Woodhead, in their paper on the secretion of carbonate of lime by animals, stated that hens supplied with any salt of lime produce normal egg-shells composed of carbonate of lime. They cannot make shells from magnesium or strontium carbonate. Crustacea, such as crabs, cannot assimilate sulphate of lime from the sea-water to form their exo-skeleton. They can form their shells from calcium chloride. In the egg-shell, the organic and inorganic material are both secreted by cells separated from the epithelial cells. In the crab-shell, the organic material (chitin) remains attached to the epithelial cells, and in this the lime salts are deposited, probably by a process of dialysis, while in the case of bone, the cells are not epithelial in character, the matrix, though separate, is closely associated with the cells, especially during its formation, and the lime is deposited in the matrix, apparently by a process of dialysis. Phosphoric acid, combined with alkalies and alkaline earths, acts as the carrier of the lime salt to the secreting cells. While in the blood, the lime salt is as a phosphate, it may be thrown out mostly as carbonate on meeting nascent carbonic acid at the secreting cells. Lime salts, of whatever form, are deposited only in vitally inactive tissue, such as bone matrix, chitin, or tissues that have undergone degeneration. Although the tissue be dead, deposition may go on. Carbonate of lime may be formed in sea-water as follows: the carbonate of ammonia produced by the decomposition of the effete products of animals, urea, &c., decomposes a portion of the sulphate of lime in the sea-water with the formation of carbonate of lime equivalent in amount to the carbonate of ammonia thus formed.

Sir John Lubbock read a paper on the shape of the oak-leaf and the leaves of the Guelder roses. The leaf of the evergreen oak is small in comparison with that of the English oak, and its margin is entire. During winter the leaf is protected by scales, which are not proportionately larger in the English oak; hence the leaf must be more folded in the bud, and the peculiar shape of the leaf may be shown by models to be due to the shortness of the bud in comparison with the length of the leaf; moreover, the two sides of the leaf are differently curved, hence the asymmetry. With regard to the Guelder roses, there are two species in this country which have very dissimilar leaves: in one form they are oval and very hairy when young; in the other they are trilobate, smooth, and furnished with stipules. In the former species the hairy covering protects the young leaves, but in the latter the outer leaves become tough and leathery, and encircle and protect the younger leaves; this brings about a close packing of the young leaves, which are folded so as to be stowed away in a small space; hence their trifid form. The presence of stipules is always associated with a lobed form of the leaf, and they apparently assume their thread-like form to fill up a space which would otherwise be left empty in the bud.

The object of the paper on the placentation of the dugong, by Sir W. Turner, was to put on record the fact that the placenta of the dugong is zonary and *non*-deciduate; it differs, therefore, in the latter character from the elephant, and in the former from its near ally the manatee.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The summary statement of lectures delivered during the past year shows that about ninety-five courses of lectures have been given in the subjects of the Faculty of Natural Science.

We may note the following among the lectures announced for this term:—

Prof. Sylvester will lecture on the resolution in integers of systems of linear equations with rational coefficients, and will reproduce an unpublished course of lectures given at King's College in 1869, on the relation of the theory of compound partitions of numbers to certain geometrical theories. Prof. Pritchard will lecture on planetary theory and on the Constellations.

Prof. Clifton, magnetism; Mr. Selby, the mathematical theory of electrostatics and magnetism.

Prof. Odling, diacidic olefine acids.

Prof. Green, stratigraphical geology and physical geology; Mr. Badger, palæontology.

Prof. Burdon Sanderson is unfortunately prevented from lecturing by serious illness, and Mr. Gotch and Dr. Haldane will lecture for him.

Dr. Tylor lectures on the development of religions, and Mr. Mackinder on the physical geography of the British Islands.

In the Medical Faculty, Mr. Thomson lectures on osteology, Dr. Collier on the methods of diagnosing disease of the heart, and Mr. Morgan on clinical surgery.

Scholarships and Exhibitions in Natural Science are offered for competition before Christmas by Balliol, Christ Church, and Trinity, and by Keble College.

CAMBRIDGE.—The Vice-Chancellor (Dr. Searle), in laying down his office, was able to relate that the executors of Mr. Newall had agreed to the conditions proposed to be made by the Senate as to the great telescope to be given to the University. The expense of transit, re-erection, and permanent work in promotion of stellar physics will be considerable.

The election of Mr. Jenkinson as Librarian gives the University an official who, in addition to his well-known classical and literary accomplishments, has no mean scientific qualifications. He was for some time Curator in Zoology, and is a member of the Botanic Gardens Syndicate and of the Council of the Cambridge Antiquarian Society. Men of science cannot regret Mr. Clark's retirement from the contest, for he literally could not be spared from the Museums, though otherwise highly qualified for the Librarianship.

There are very few new features in the science lectures this term. The list is, if anything, slightly longer, and would fill two of our pages; but there is nothing in it calling for special comment.

SCIENTIFIC SERIALS.

THE *American Meteorological Journal* for September contains (1) an article by Prof. H. A. Hazen on cloud formation. The author considers that theories of storm generation and cloud formation are unsatisfactory. He has made a number of experiments, both with dry and damp air, on the formation of cloud by the cooling produced by exhaustion, the result being that he finds the amount of the latter to be only about one-fourth of what theory would indicate. The results obtained with dry and moist air were almost exactly the same. (2) State tornado charts for Alabama and Ohio, by Lieutenant Finley. (3) An article on the verification of weather forecasts, by H. Helm Clayton. He points out that all the methods adopted admit of considerable latitude in interpreting phenomena, so that the same forecasts, when verified by different persons, may differ widely as to the percentage of success, and he suggests an arrangement which may be applied to areas as well as to single stations, and which, at the same time, might be useful in studying the relative frequency of each phenomenon. (4) The distribution of wind velocities in the United States, by Dr. F. Waldo, deduced from the records of the self-recording anemometers at the stations of the Signal Service. In this article, which is unfinished, the author deals exclusively with the values of the constants derived from various anemometrical experiments in Germany and Russia.

THE *Meteorologische Zeitschrift* for September 1889 contains a discussion, by Dr. J. Hann, of Parts iv. and v. of "Contributions to our Knowledge of the Meteorology of the Arctic

Regions," lately published by the Meteorological Council (see NATURE, vol. xxxviii. p. 625). He fully recognizes the value of this work, and the importance of a similar discussion of the observations collected during later expeditions. Dr. J. M. Pernter contributes an epitome of the Report of the Krakatão Committee of the Royal Society. Among the smaller "communications" may be mentioned (1) the description of a new registering apparatus for rainfall and wind, with electrical connections, in which the influence of the elements themselves is made to move the paper form, and the clock to record the indications, instead of the usual plan of the clock moving the paper (the principles of such an instrument were also referred to in the *Zeitschrift für Instrumentenkunde*, 1882, p. 206, and 1884, p. 300); (2) a note by Dr. Köppen, on the construction of isobars reduced to the level of 2500 metres, instead of to sea-level (the proposed plan is especially intended for use over large areas, where the differences of pressure and the altitudes of the stations are considerable, as, for instance, in Austria).

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, October 7.—M. Des Cloizeaux, President, in the chair.—Complement to the theory of thin weirs extending throughout the breadth of the bed of a water-course; approximate calculation, for depressed sheets, of the non-pressure at their lower face, according to the elevation of the surface down-stream, by M. J. Boussinesq.—New observations on the reciprocal displacements between oxygen and the halogens, by M. Berthelot. Fuming hydrochloric acid, in contact with air, does not yield chlorine, even after prolonged exposure to sunlight; but the addition of certain metallic chlorides (especially manganous chloride) causes it to react with oxygen, forming chlorine and water. This change is due to the formation and decomposition of a perchloride of manganese. Its bearing on thermo-chemical theory is pointed out.—On Raffinose, by the same. He describes a new hydrate, got by crystallization from aqueous alcohol, the formula being $C_{18}H_{32}O_{16} \cdot 6H_2O$ (the former one had $5H_2O$). Raffinose ferments wholly, with good beer-yeast. But with weak baker's yeast, the process stops, after forty-eight hours, when about a third has been affected. The raffinose seems to be broken up into a glucose, which ferments and disappears, leaving either a second sugar of the saccharose family, with a certain reducing power, or a mixture of two glucoses (one reducing).—Effects of an intermittent wind in soaring, by M. Marey. A ball let off at the top of a board with sinuous profile, and descending series of heights, surmounts all those heights by gravity. Let off from the lowest height, it may be got back to the highest, if, each time it is rising, the board be jerked horizontally in the opposite direction. This experiment, suggested by M. Bazin, is applied to the case of the bird; an intermittent wind, acting as the bird rises, may enable it to gain height after each descent. (The movements of the ball M. Marey represents by photo-chronography.)—On transformism in micro-biology; limits, conditions, and consequences of the variability of *Bacillus anthracis*; researches on descendant or retrograde variability, by M. A. Chauveau. By continuous action of compressed oxygen on the *Bacillus*, one can obtain less and less resistant races or types, especially sensitive to the action of the attenuating agent, till at length they are found unable to vegetate in contact with it. Up to this limit, however, the *Bacillus* is pathogenic. It loses virulence, but keeps the vaccinal property throughout its existence. These new characters may be easily maintained by cultivation. And these special types of the *Bacillus* perhaps exist in nature.—On the invariants of certain differential equations and on their applications, by M. R. Liouville.—Determination of the difference of longitude between Paris and Madrid; an international research, carried out by MM. Esteban and Bassot. In 1863, MM. Le Verrier and Aguilar determined this difference indirectly, by measuring those between Paris and Biarritz, and Biarritz and Madrid. A direct determination was very desirable for geodetic purposes; and this, made with Brunner's portable meridian circles, and comparison of pendulums by chronographic inscription of telegraph signals (without relays) yields the value 24m. 6·00s. as against 24m. 6·08s. (Le Verrier).—On surfaces of which the ds^2 may be brought in various ways to the type of Liouville, by M. G. Kœnigs.—Synthesis of some oxygenated selenium compounds, in the aromatic series, by M. C. Chabrié.—Researches on fucusol, by M. Maquenne. This substance, obtained by Stenhouse from seaweed, proves to be a mixture of furfurol (10 parts) and methylfurfurol (1 part); the name should therefore be given up.—On the physiology of the trachea, by M. Nicaise. In normal, calm respiration, the trachea remains contracted, with unvarying diameter, the ends of the rings nearly in contact, also the borders. In strong respiration (shouting, singing, [&c.) the trachea dilates and elongates in respiration, the larynx rising; the reverse occurs in inspiration. He succeeded in registering these rhythmic movements. The dilatation is greatest at the upper part; it is permitted by the membranous portion, and is due to mechanical pressure of air. Compression of air by the dilated trachea plays an important part in singing, &c.—On the pathology of nerve-terminations of muscles of animals and of man, by MM. Babes and Marinesco. By a new colouring method, they are able to follow the minute structure, and its alterations in atrophy, hypertrophy, segmentation, &c.—On a new *Proteromonas*, by M. J. Kunstler. This, found in the gray lizard of Gascony, is of S shape, and has a very long flagellum, two to five times as long as the body, starting usually from a globular enlargement. The name proposed is *P. dolichomastix*.—On the presence of pectic compounds in plants, by M. L. Mangin. These substances, he finds, play an important, if not preponderating *rôle* in the formation and growth of membrane; and he indicates methods of detecting their presence.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

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