THURSDAY, OCTOBER 15, 1891.

PHYSICAL CHEMISTRY.

Outlines of General Chemistry. By Wilhelm Ostwald. Translated with the Author's sanction by James Walker, D.Sc., Ph.D. Pp. 396. (London: Macmillan and Co, 1890.)

THAT much may be gained by a judicious use of the methods of the physicist in elucidating chemical phenomena most chemists will admit; and, considering the rapid strides made of late years in physical chemistry, it seems surprising that so little has been done to give a connected account, suited to the wants of the student, of the main researches in this important field of investigation. Original communications on physical chemistry are on the increase. The chemist has now, in the *Zeitschrift für physikalische Chemie*, a periodical devoted exclusively to this branch of his science, and during the four years or so of the existence of this journal, its success has testified amply to the want which it supplies.

Ready access to original memoirs is not, however, the boon of the ordinary student; and, even if it were otherwise, the want of some scheme whereby to systematize his reading and classify his information, much of which is still open to wide difference of opinion, would almost invariably lead to confusion.

The majority of the text-books make little or no attempt at supplying this want. Occasionally a few of the larger chemical treatises spare a few pages to "physical methods," and such text-books as Meyer's "Modernen Theorien" or Muir's "Principles of Chemistry" contain much of the matter classed under physical chemistry.

Yet a comprehensive idea of what has been done in tracing relationships between physical properties and chemical composition and in utilizing physical measurements in investigating chemical change, cannot be obtained from most text-books. Indeed, so far as we know, only one is designed to serve this purpose, and that is the "Lehrbuch der Allgemeinen Chemie" of Prof. Ostwald. "Allgemeinen" rather than "Physikalische" "Chemie" has been used as a title for the work; but in the main it deals with physical chemistry. The book under notice seems to be an English translation of an abstract of the "Lehrbuch"; and, were it for no other reason than that it furnishes a well-conceived syllabus of the subject-matter of general and physical chemistry, it would be worthy of careful consideration.

The book is divided into two parts—Part I. chemical laws of mass; Part II. chemical laws of energy.

The first part opens with stoïchiometry. The laws of chemical combination, the determination of atomic weights, and a useful summary of the atomic weight estimations of the different elements are here given. Then follow sections treating of such of the physical properties of gases, of liquids, of solutions, and of solids as the chemist must be familiar with, and of the more important relations which have been established between such physical properties and chemical composition.

The section dealing with solutions is noteworthy as containing the first fairly complete statement, in an English text-book, of the facts grouped around the physical theory of solution which has arisen out of a knowledge of osmotic pressure. Part I. closes with chapters on chemical systematics—the choice of atomic weights, the periodic law, the development of the present conception of molecular structure.

In the earlier portions of the second part, thermochemistry, photo-chemistry, and electro-chemistry are discussed. The last takes up the constitution of electrolytes, electric conductivity, and the Arrhenius dissociation hypothesis.

Chemical dynamics and chemical affinity are treated in the last two sections, and afford many illustrations of the use of physical methods in the study of chemical change. In the case of acids competing for the same base are found instances where physical methods alone are available to estimate the nature and extent of the chemical action. In these sections, the exposition of the law of mass action, and of the velocity of chemical change, is especially clear. Owing to recent work on the subject, the discussion of affinity is here more complete than in the "Lehrbuch," and however unsatisfactory the notion of fixing specific affinity constants be considered, the account set out is the most systematic and plausible yet published.

There is no doubt that the general conception of the book is admirable; it contains much that is new; to the advanced reader it will be refreshing after the time-honoured methods of the ordinary text-books. Yet the general impression which we think will be formed on looking through it, is that the attempt made to compress information into too small a compass has detracted much from its value.

A certain amount of detail is always necessary to intelligent comprehension, and in many parts of the book there is too much bald statement to satisfy the reader who approaches the subject for the first time. Mainly for this reason it is a question whether the work will answer the expectation of the author that it will "meet the requirements of the student who, while not intending to devote himself to the detailed study of general chemistry, still wishes to follow *intelligently* the progress recently made in this important branch of science."

The time which has been spent in preparing the chapters on several important topics seems to have been inadequate. For instance, the molecular volumes of liquids are disposed of in little more than three pages. Kopp's laws are quoted, although not one of them can now be taken as valid; Schiff's inaccurate rule as to the volumes of isomers also finds a place. Instead of apparently settling the question by stating "molecular volumes to be additive magnitudes subject to constitutive influence," little more space would have been occupied in showing how, in different groups of isomers, the volume varies with the constitution. If recent progress on the subject was to be made use of, the facts that the effects of molecular weight and constitution cannot be disentangled, that even from the comparison of compounds of similar constitution, definite atomic volumes, determined for the boiling-point, cannot be obtained—that, in short, atomic volumes cannot be regarded as physical constants—ought surely to have been emphasized.

The desire to economize space is probably the cause of several examples of rather mixed information. The following paragraph occurs on p. 104:—

"Ordinary dextrotartaric acid, for instance, has precisely the *same properties* as lævotartaric acid; but the compound of both which crystallizes from their mixed solutions on evaporation—racemic acid—has quite a different character. The first-named crystallize anhydrous, the last hydrated. The simple acids do not precipitate a solution of calcium sulphate. The compound acid does, and so forth. Yet it should be emphasized that such *differences* only occur with *solid* compounds; racemic acid behaves in *solution like a mixture* of the two components."

Seeing that this book is one of the very few in which Van der Waals's work obtains the prominence which it deserves, and which has been long delayed, it seems a pity that pains have not been taken to make the account accurate.

On p. 67 the reader is led to infer that *b* in Van der Waals's equation is the volume of the molecules; the true value of *b* is four times the volume of the molecules. Again, on p. 90, it is stated that the equation "is deduced only for the case where the volume of the substance is eight times as large as the magnitude *b*"; correctly given, this should be, "is deduced for cases where the volume is greater than 2*b*."[1]

Admirable as may be the exposition of the theory of solution from the advanced standpoint here taken up, it may rightly be questioned whether the student is fairly treated. The physical theory of solution, the dissociation hypothesis, no one knows better than the author, are still strongly contested: should the student therefore not have heard a little more of the other side of the question? Particularly objectionable is the application of such terms as Boyle's law, Gay Lussac's law, &c., to solutions. In the opening chapters of the book the reader is familiarized with the kinetic theory of gases; he is enabled to form a mental picture of the mechanism which results in the pressure of a gas. How he, or, indeed, anyone, can form a similar picture for a solution, when the molecules of the solvent have also to be taken into consideration, it is difficult to imagine. By using for solutions a term such as Boyle's law, which for gases is capable of a perfectly definite interpretation, the real difficulty of the question is ignored, and misconception is almost sure to arise, especially in the case of the beginner.

We noticed in passing that, on p. 364, polybasic is used for dibasic; on p. 370, $k_1a = k'_2h^2a$ should be $k_1a = k'_1h^2a$. Frequently there is no distinction between the type of letters occurring in formulæ, and that in which the book is printed. Reference in the body of the book to portions of formulæ is therefore apt to lead to confusion, and in any case lacks clearness, as may be seen on pp. 297 and 369.

The work, from its very title, apart even from the reputation of the author, will no doubt appeal to a large class of readers; as an English text-book of chemistry it is unique. We venture to think, however, that if such points as those indicated were attended to, particularly the question of space, its sphere of usefulness would be materially enlarged. J. W. R.

[1] Physical Society Memoirs, i. 3, 453.

UNITED STATES FISH COMMISSION REPORTS.

Bulletin of the United States Fish Commission. Vol. VIII. for 1888. (Washington, 1890.)

IN 1881 the Senate and House of Representatives of the United States of America authorized the public printer to print from time to time any matter furnished to him by the United States Commissioner of Fish and Fisheries relative to new observations, discoveries, and applications connected with fish culture and the fisheries. The printed matter was to be capable of being distributed in parts, the whole was to form an annual volume or Bulletin not exceeding 500 pages, and the edition was to be limited to 5000 copies.

Seven volumes of this important series have since been published, and have been noticed in our pages. They were composed chiefly of translations or republications of articles on fish or fisheries which had appeared in European periodicals or as State documents; extracts from the official correspondence, with statistics of work done; and often of short articles of direct scientific interest on American fish; the whole forming a most valuable, practical encyclopædia of everything relating to the economic study of fish.

An eighth volume, dated 1890, but being the Bulletin for 1888, has just been issued from the Washington Press. The increased operations of the United States Fish Commission during 1888 have made it possible to devote almost the whole of this volume to the results of the work of the Commission, and it will be found to contain matter of considerable interest. The size of the volume has been slightly enlarged, so as to afford room for larger illustrations.

Of the twelve memoirs or papers contained in this volume, five relate to local collections of fishes. Mr. Tarleton H. Bean gives notes on a collection made at Cozumel, Yucatan: sixty species are enumerated; two new species are described and figured. Mr. C. H. Bollman reports on the fishes of Kalamazoo, Calhoun, and Antrim counties in Michigan. Mr. S. A. Forbes contributes a preliminary account of the invertebrate animals inhabiting Lakes Geneva and Mendota, in Wisconsin, and gives some particulars of the fish epidemic in the latter lake in 1884. Mr. C. H. Gilbert describes some fish from the lowlands of Georgia. Mr. D. S. Jordan gives a report of explorations made during 1888 in the Alleghany region of Virginia, North Carolina, and Tennessee, and in Western Indiana, with an account of the fishes found in each of the river-basins of those regions.

In a review of the genera and species of Serranidæ, by D. S. Jordan and C. H. Eigenmann, we have an enumeration of all the genera and species belonging to this family found in the waters of America and Europe, together with the synonymy of each, and analytical keys by which the different groups may be distinguished. One hundred and nineteen species are admitted, and thirty-four genera. This memoir is illustrated with ten plates. Mr. J. W. Collins contributes a paper on improved types of vessels for use in the market fisheries, with some notes on British fishing-steamers; and Mr. W. F. Page gives an account of the most recent methods of hatching fish-eggs. Mr. T. H. Bean reports favourably on the feasibility of introducing the mountain mullets of Jamaica (Agonostoma) into some of the Alpine streams of the Southern States; and Mr. R. Rathbun gives a detailed report on the introduction of lobsters to the Pacific shores of the United States.

The two most important contributions to this volume are, however, those by Lieutenant Tanner, "On the Result of the Explorations of the Fishing-grounds of Alaska, Washington Territory, and Oregon during 1888," and by Mr. John A. Ryder, "On the Sturgeons and Sturgeon Industries of the Eastern Coast of the United States."

Although it had been known for many years that the Pacific coasts of North America were abundantly provided with edible fishes, it was not until 1880 that the exact species of these were correctly determined; the Alaskan cod proving to be the same species as that of the North Atlantic. The absence of large and convenient markets hindered the development of the Pacific coast fisheries; but, with the completion of the railroad system, this state of things has changed, and a strong interest is now being shown in all that relates to the development of the fish industry. This Report affords us the first accurate information that has been obtained respecting most of the fishing-grounds in Alaska. The five banks whose positions were indicated by older surveys—namely, Davidson, Sannakh, Shumagin, Albatross, and Portlock banks—were more thoroughly examined than were the intervening areas, some of which, however, may, upon further examination, prove to contain fishing-banks of equal value, and not inferior in size, to at least the smaller of the banks mentioned.

Good fishing was obtained at nearly all localities where trials were made with hand-lines, whether upon defined banks or upon the more level grounds between them, and it seems natural to infer that the entire submerged plateau from off Unalashka Island to Fairweather Ground is one immense fishing-bank, limited upon the outer side only by the abrupt slope, which may be said to begin about the 100-fathom curve.

Although the great bulk of this Report relates to the fishing-banks and fishes, yet we get various glimpses of many interesting facts relating to other of the vertebrate and to many of the invertebrate forms met with. Off Popoff Island, large masses of sea-urchins, star-fishes, and large Medusæ were found in the seine nets, and the hooks became entangled with fine specimens of sea-pens (Pennatula). At the Lighthouse Rocks a landing was made, to examine a large rookery of Steller's sea-lion (*Eumetopias stelleri*). Several hundreds of these animals were found crowded together upon a very limited area. As the party landed, the old sea-lions came tumbling down over the rocks in great eagerness to reach the sea; a few, whose retreat was intercepted, were seen to jump from their high positions directly into the water, apparently sustaining no injury from the plunge, although the distance was considerable, especially for such large animals. A couple of killer whales (Orca), attracted by the disturbance and the sight of so many seals in the water, came quite close to the rocks, causing the seals to gather nearer the shore, and to cast frightened looks of alarm towards the whales, whose dorsal fins showed not less than four feet above the surface of the water. These rocks were entirely destitute of vegetation. Off Trinity Islands, large quantities of crustaceans, worms, mollusks, echinoderms, and sponges were taken—an especial feature of the haul consisting of over a hundred specimens of a fine large free crinoid. As all these specimens will find their way to the United States National Museum, we may expect soon to have recorded many additions to the marine fauna of the North Pacific.

Mr. John A. Ryder's paper will also be perused with great interest. Having undertaken to report on the sturgeons and sturgeon fisheries of the eastern rivers of the United States, he repaired in May 1888 to Delaware City, which is described as a very important centre of the sturgeon fishery. Two species of the genus Acipenser are to be found in the waters along the Atlantic coast of the United States; these are *A. sturio*, L., and *A. brevirostris*, Le Sueur. The former (the common sturgeon) is the only one of any commercial importance at Delaware, as Le Sueur's species is so rare that only five specimens of it were taken by Mr. Ryder; and since the date of its first being described, in 1817, it does not appear to have been until now again recognized. Of the other American species, one is the very distinct fresh-water sturgeon of the Lake region, and two others are to be found on the Pacific coast.

The embryological data of this memoir have been in a good measure drawn from the author's original investigations, but he has fortunately also given us in addition details from the writings of Balfour, Knoch, Parker, Zograff, and Salensky. He found it perfectly practicable to fertilize artificially the sturgeon's roe, and thinks it possible that millions of young sturgeon might be developed in this way. He treats in detail of the dermal armature of the sturgeon's body, illustrating this part of his subject by numerous photogravures, describes the organs of locomotion, the lateral line system, the viscera, and lymphatics. The sources of the food of this fish and its peculiar habits are next considered, and special information is given about the preparing of the flesh for market, and the manufacture of the caviare. A very useful bibliography of the literature relating to the sturgeon is appended. This memoir is illustrated by twenty-two plates.

THE CATALOGUE OF THE WASHINGTON MEDICAL LIBRARY.

Index Catalogue of the Library of the Surgeon-General's Office, U.S. Army. Vol. XI. Phædronus—Régent. Pp. 1102. (Washington, 1890.)

THE appearance of these very fine folios year by year for the last eleven years is a very good proof to all lovers of books and collections of books in Europe that they have some sympathetic friends in America who have the will and the power to make one at least of their finest libraries well known throughout the world. Its title as the Library of the Surgeon-General's Office may once have sounded like the name of a collection of musty Blue books tied together with red tape; but, thanks to the energy of its Librarian, Mr. J. S. Billings, which we feel constantly in the monthly publication of the *Index Medicus*, everyone knows now that it is nothing of the kind, but one of the first medical libraries, if not the first, in the world, containing much more medical literature than is to be found in the libraries of the richer English corporations, the Royal Colleges of Physicians and Surgeons, or of the more learned and active Societies, such as the Royal Medical and Chirurgical Society, or, indeed, in the British Museum or Bibliothèque Nationale. And though the Washington Library is of comparatively recent date, going back only some thirty years, yet it contains a very fine collection of books both of the fifteenth and sixteenth centuries; and at the same time the great difficulty of the maker of a catalogue to a modern library, viz. the immense mass of the newspaper and periodical literature of to-day, has been fairly faced and overcome. During the past year, 287 periodicals have been added to the list of those that are taken in, raising the total number to about 7500, of which at least 3900 are current. The vast aggregate of articles in these are duly catalogued, each under the head of its subject-matter. It is not surprising, therefore, that we should find 80 of these large square folio pages filled in the present volume with entries under the heading Phthisis, 78 under Puerperal Diseases, 67 under Pregnancy, and 56 under Pneumonia. Even as devoted entirely to a lesser matter like the pulse, there are catalogued 150 volumes and 350 articles in periodicals. The care with which the records of the smallest steps in the past history of medicine have been preserved is shown by the accumulation of twenty-five editions of the "Pharmacopœia" of the Royal College of Physicians of London from the years 1657 to 1851. Under such headings as Psychology, we may see the wide range also of the larger subjects embraced in the Library, for the collection under this heading begins with many expositions of Aristotle, and does not neglect Plato, but takes in also the recent books of modern authors, such as the last edition of Herbert Spencer's "Principles of Psychology" and Taine's "De l'Intelligence." The eleventh volume of this magnificent catalogue brings us to within measurable distance of the end; from the analogy of lesser works, in fact, it seems probable it may be completed in three or at most four volumes, and it will then be a great monument among modern catalogues, and in its articles under subject titles form a most valuable dictionary to all who are seeking a clue to the complete historical study of medicine and surgery.

A. T. Myers.

OUR BOOK SHELF.

Dictionary of Political Economy. Edited by R. H. Inglis Palgrave, F.R.S. Part I. Abatement—Bede. (London: Macmillan and Co., 1891.)

This is a first instalment of what promises to be a very valuable addition to the English library of political economy. The plan of the work is laid down on broad lines, and includes not only articles dealing with strictly economic subjects, and explanations of legal and business terms, but good (though necessarily brief) accounts of historical events bearing on economic history, such as the establishment and downfall of the *ateliers nationaux* in Paris in 1848, and biographical notices of deceased writers whose life and work has had any connection with the development of economic theory or practice. That the biographical section of the dictionary is conceived in a liberal spirit is sufficiently proved by the fact that the first part, now under review, includes notices of Addison and Thomas Aquinas; the claim of the former to a place in a dictionary of political economy is based in the main on the fact that he held an official position in the Government of his time as one of the Lords Commissioners of Trade. This rather remote connection with economics may be open to criticism; and it remains to be seen whether Mr. Palgrave will include in his dictionary the honoured names of William Wordsworth and Robert Burns. It is not, however, desirable to say anything in the way of criticism which should tend to narrow the scope of the work. Its interest and vitality depend, to a large degree, on its broad inclusiveness.

The biographical articles are particularly well done, and we would single out that on the late Mr. Bagehot for special commendation. It gives not only the dry facts of his career, but presents a living picture of a peculiarly fascinating personality, and also a very just estimate of his place in, and services to, economic literature. Among the most important articles in the present instalment of the dictionary may be mentioned that on agricultural communities, by Prof. J. S. Nicholson, and that on banks. The former gives an admirable summary of the conditions of life in existing village communities in Russia and India, and also a digest of the results arrived at by the researches of Sir Henry Maine, Mr. Seebohm, and M. de Laveleye, as to the existence of various forms of village communities in the remote past in our own and other countries. The article on banks gives an historical sketch of the development of banking in various countries, contributed by different writers, each with special knowledge of his own portion of the subject. Thus we have brought together within the compass of a few pages an account of the land banks and the Schulze Delitsch credit banks of Germany, the savings banks (trustee and Post-office) of England, and the popular banks of Italy.

The names of the contributors to the present volume, and also those who have promised their assistance in the preparation of the rest of the work, are a guarantee of its high value to all students of social and economical subjects.

South Africa, from Arab Domination to British Rule. Edited by R. W. Murray, F.R.G.S. With Maps, &c. (London: Edward Stanford, 1891.)

One of the objects of this book is to bring out the contrast between Portuguese rule in South Africa and the influence exerted by England. The contrast is certainly striking enough; and it is shown most clearly, as in the present work, by a simple statement of historic facts. In the first chapter, Prof. Keane sketches the career of the Portuguese in the various South African regions they have dominated. This is followed by translations from the "Africa" of Dapper, a Dutch writer of the seventeenth century, showing that at that time the Portuguese stationed on the African coasts made no effort to acquire extensive knowledge of the interior. The editor then records the main facts relating to the Dutch and English settlements in the south, and the recent movements northward to Bechuanaland, Matabeleland, and Mashonaland. Mr. J. W. Ellerton Fry, late of the Royal Observatory, Cape Town, Lieutenant of the British South African Company's expeditionary force, gives an account of what he himself observed during the march into Mashonaland in 1890; and much information with regard to the east coast of Africa at Beira, Pungwe, and the Zambesi is presented in notes from the diary and correspondence of Mr. Neville H. Davis, late surveyor and hydrographer to the Queensland Government, who, in 1890, accompanied an expedition sent to East Africa to discover whether there was any mineral or other wealth in concessions granted by the Mozambique Company. The book has not been very systematically planned; but it brings together so many facts which are not readily accessible elsewhere, that it cannot fail to interest readers whose attention is for any reason especially directed to South Africa. It includes several excellent maps, and two engravings of Cape Town, showing Cape Town as it was in 1668, and as it is in 1891.

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.*]

A Pink Marine Micro-organism.

WHILE dredging lately in Loch Fyne, I noticed through the clear water, in a little shallow bay on the north side of the entrance to East Loch Tarbert, a number of pink patches on the sand. These could just be reached by wading from a boat at the lowest tides, and were then found to be roughly circular spots, about a foot in diameter, where the clean white sand was discoloured, most of the surface grains being almost exactly the tint of ordinary pink blotting-paper.

Under a low power of the microscope, it is seen that the pink particles are ordinary clear quartz sand-grains, incrusted with little bright pink jelly masses, generally of elongated or sausage-like forms, and averaging 0·1 mm. in length. Further magnification shows that each jelly mass is crowded with minute very short rods, or ellipsoids, of about 0·0015 mm. in length, and about half as much in breadth.

This appears to be a micro-organism in the zoogl œa condition, and I do not know that any such pink marine form, living on clean sand, in *pure* sea water, has been noticed. It may possibly be one of the forms of *Beggiatoa rosea-persicina*, but it does not agree satisfactorily with any of the descriptions I have access to here. I have still some of the material alive in sea water, and shall be glad to hand it over to any biologist who is now working specially at such forms, and would like to investigate this one.

W. A. HERDMAN.

University College, Liverpool, October 6.

Advertisements for Instructors.

THE friends of technical education can no longer complain that the subject is not receiving attention. The numerous advertisements for instructors of all sorts, from County Councils and other bodies, colleges and schools are full evidence that much is being attempted.

Whether all the plans and proposals and experiments will lead to the hoped-for results only time will show. Some of us have our doubts as regards many of them.

Meantime, one of the advertisements deserves a passing notice. A well-known technical school is in search of "a demonstrator in the Metallurgical Department to take the lectures in geology and mineralogy, and to give instruction in dry assaying and in iron and steel analysis" (see NATURE of this week).

This is certainly a large and considerably mixed "order," calculated to make thoughtful people wonder what sort of instruction is expected to be given by this gifted person (who is to have the princely sum of £100 per annum); and whether, if the "metallurgical demonstrator" is to throw in geology and mineralogy as a sort of extra to his own special work, the other demonstrators and professors are expected to be equally widely qualified; let us say a chemical demonstrator to give lectures on mechanical engineering and ship-building?

Newcastle-on-Tyne, October 10. M.

"Rain-making."

I THINK the following will be of interest to your readers in connection with the "rain-making" experiments in Texas. On October 1, at 5 p.m., five tons of gunpowder was exploded in a single blast at the Penrhyn slate quarries in order to clear away a very large mass of useless rock. A strong wind had been blowing all day, and the clouds, though heavy, were high; there had been no rain, and not much sunshine, and the temperature was somewhat low.

Immediately after the explosion the wind fell to a dead calm, which lasted about 5 or 6 minutes, and 20 minutes later a fine rain began to fall, which soon became heavy and continued for an hour and a half. By 7 p.m. all disturbances produced by the explosion had apparently passed away, and the weather was again similar to what it had been during the day. The rainfall was entirely local, there being none, as far as I could learn, outside a radius of 6 or 7 miles from the quarry.

W. R. PIDGEON.

Alum Solution.

WITH reference to the question raised by Mr. H. N. Draper in NATURE, vol. xliv. p. 446, as to the practical superiority of an alum solution over simple water in absorbing such radiations as are chiefly instrumental in producing heat, I may recall some experiments made by myself five years ago (Brit. Assoc. Report, 1886, p. 309). The source of radiation employed was a paraffin lamp with a glass chimney, the various solutions were contained in a glass cell with parallel sides, and the "radiometer" was a delicate thermopile, the face of which was blackened with camphor smoke. The following results, among others, were obtained:—

Solutions, &c.	Diathermancy.
Empty cell	1000
Water distilled	197
Water from tap	200
Alum, saturated solution	204

It is clear therefore that, at least under conditions like those of my experiment, plain water will answer the purpose of an absorbent rather better than an alum solution. Possibly the "alum cell" tradition rests upon no better foundation than many others, which are generally accepted simply because it does not occur to people to question them.

SHELFORD BIDWELL.

October 10.

B.Sc. Exam. Lond. Univ. 1892.

THERE are, I believe, in London at the present time a number of men desirous of offering geology as one of three subjects required at the Degree Examination in Science, but who are deterred from so doing by the fact that it is impossible to obtain adequate evening class tuition in this subject.

Enquiries at the various teaching institutions have failed to discover a single opportunity for working up to the required standard in both theoretical and practical branches.

I have therefore laid the matter before Prof. Wiltshire, of King's College, Strand, with the result that he has very kindly consented, in the event of enough men requiring it, to supplement his lectures on geology and mineralogy by a course of instruction in petrology, embracing the study of hand specimens and microscopical examination of rock sections.

By giving publicity to the matter, it is hoped that a sufficient number of B.Sc. candidates will be forthcoming to ensure the establishment of this class.

The time-table for the complete course will be as follows:—

Monday	Petrology ...	6–7 p.m.
	Mineralogy ...	7–8 ,,
	Geology ...	8–9 ,,

The lectures and practical work, together with the summer field excursions, under the direction of Prof. Wiltshire, will prove a great boon to such as are prevented from attending day courses, and will undoubtedly secure admirable preparation for the examination specified.

I shall be glad to hear from anyone interested in the matter, so that arrangements may at once be made for the first sitting to take place on Monday, October 19.

EDWARD J. BURRELL.

People's Palace, Mile End Road, E.

Some Notes.

THOSE who have visited Venice in spring know how rampant mosquitoes become after the flight of the swallows, which have kept them in check, for the north—usually in May.

A word for the sparrows—which have been very active in the gardens hereabouts this season, preying on the green flies and larvæ infesting the creepers and ferns in particular; but very few starlings have been observed, to the great increase of earth-worms in the lawns. The crane-fly, which usually swarms in the fields of the Mansfield estate in September, has been very rare, too, this season. The dragon-fly visited us this summer for the first time.

Apropos to the records of the "rare phenomenon," such a summer aurora was observed at Rothbury, Northumberland, in the latter half of August 1880.

To conclude this farrago of notes: for "*non* pas travaillés" in Mr. Sclater's quotation of the Prince of Canino's words (xliv. p. 518), read "*n'ont* . . ." J. J. Walker.

Hampstead, N.W., October 3.

THE MOLECULAR PROCESS IN MAGNETIC INDUCTION.[1]

MAGNETIC induction is the name given by Faraday to the act of becoming magnetized, which certain substances perform when they are placed in a magnetic field. A magnetic field is the region near a magnet, or near a conductor conveying an electric current. Throughout such a region there is what is called magnetic force, and when certain substances are placed in the magnetic field the magnetic force causes them to become magnetized by magnetic induction. An effective way of producing a magnetic field is to wind a conducting wire into a coil, and pass a current through the wire. Within the coil we have a region of comparatively strong magnetic force, and when a piece of iron is placed there it may be strongly magnetized. Not all substances possess this property. Put a piece of wood or stone or copper or silver into the field, and nothing noteworthy happens; but put a piece of iron or nickel or cobalt and at once you find that the piece has become a magnet. These three metals, with some of their alloys and compounds, stand out from all other substances in this respect. Not only are they capable of magnetic induction—of becoming magnets while exposed to the action of the magnetic field—but when withdrawn from the field they are found to retain a part of the magnetism they acquired. They all show this property of retentiveness, more or less. In some of them this residual magnetism is feebly held, and may be shaken out or otherwise removed without difficulty. In others, notably in some steels, it is very persistent, and the fact is taken advantage of in the manufacture of permanent magnets, which are simply bars of steel, of proper quality, which have been subjected to the action of a strong magnetic field. Of all substances, soft iron is the most susceptible to the action of the field. It can also, under favourable conditions, retain, when taken out of the field, a very large fraction of the magnetism that has been induced—more than nine-tenths—more, indeed, than is retained by steel; but its hold of this residual magnetism is not firm, and for that reason it will not serve as a material for permanent magnets. My purpose to-night is to give some account of the molecular process through which we may conceive magnetic induction to take place, and of the structure which makes residual magnetism possible.

When a piece of iron or nickel or cobalt is magnetized by induction, the magnetic state permeates the whole piece. It is not a superficial change of state. Break the piece into as many fragments as you please, and you will find that every one of these is a magnet. In seeking an explanation of magnetic quality we must penetrate the innermost framework of the substance—we must go to the molecules.

Now, in a molecular theory of magnetism there are two possible beginnings. We might suppose, with Poisson, that each molecule becomes magnetized when the field begins to act. Or we may adopt the theory of Weber, which says that the molecules of iron are always magnets, and that what the field does is to turn them so that they face more or less one way. According to this view, a virgin piece of iron shows no magnetic polarity, not because its molecules are not magnets, but because they lie so thoroughly higgledy-piggledy as regards direction that no greater number point one way than another. But when the magnetic force of the field begins to act, the molecules turn in response to it, and so a preponderating number come to face in the direction in which the magnetic force is applied, the result of which is that the piece as a whole shows magnetic polarity. All the facts go to confirm Weber's view. One fact in particular I may mention at once—it is almost conclusive in itself. When the molecular magnets are all turned to face one way, the piece has clearly received as much magnetization as it is capable of. Accordingly, if Weber's theory be true, we must expect to find that in a very strong magnetic field a piece of iron or other magnetizable metal becomes *saturated*, so that it cannot take up any more magnetism, however much the field be strengthened. This is just what happens: experiments were published a few years ago which put the fact of saturation beyond a doubt, and gave values of the limit to which the intensity of magnetization may be forced.

When a piece of iron is put in a magnetic field, we do not find that it becomes saturated unless the field is exceedingly strong. A weak field induces but little magnetism; and if the field be strengthened, more and more magnetism is acquired. This shows that the molecules do not turn with perfect readiness in response to the deflecting magnetic force of the field. Their turning is in some way resisted, and this resistance is overcome as the field is strengthened, so that the magnetism of the piece increases step by step. What is the directing force which prevents the molecules from at once yielding to the deflecting influence of the field, and to what is that force due? And again, how comes it that after they have been deflected they return partially, but by no means wholly, to their original places when the field ceases to act?

I think these questions receive a complete and satisfactory answer when we take account of the forces which the molecules necessarily exert on one another in consequence of the fact that they are magnets. We shall study the matter by examining the behaviour of groups of little magnets, pivoted like compass needles, so that each is free to turn except for the constraint which each one suffers on account of the presence of its neighbours.

But first let us see more particularly what happens when a piece of iron or steel or nickel or cobalt is magnetized by means of a field the strength of which is gradually augmented from nothing. We may make the experiment by placing a piece of iron in a coil, and making a current flow in the coil with gradually increased strength, noting at each stage the relation of the induced magnetism to the strength of the field. This relation is observed to be by no means a simple one: it may be represented by a curve (Fig. 1), and an inspection of the curve will show that the process is divisible, broadly, into three tolerably distinct stages. In the first stage (*a*) the magnetism is being acquired but slowly: the molecules, if we accept Weber's theory, are not responding readily—they are rather hard to turn. In the second stage (*b*) their resistance to turning has to a great extent broken down, and the piece is gaining magnetism fast. In the third stage (*c*) the rate of increment of magnetism falls off: we are there approaching the condition of saturation, though the process is still a good way from being completed.

Further, if we stop at any point of the process, such as P, and gradually reduce the current in the coil until there is no current, and therefore no magnetic field, we shall get a curve like the dotted line PQ, the height of Q showing the amount of the residual magnetism.

If we make this experiment at a point in the first stage

[1] Abstract of a Friday Evening Discourse delivered at the Royal Institution, on May 22, 1891, by J. A. Ewing, M.A., F.R.S., Professor of Applied Mechanics and Mechanism in the University of Cambridge.

(*a*), we shall find, as Lord Rayleigh has shown, little or no residual magnetism; if we make it at any point in the second stage (*b*), we shall find very much residual magnetism; and if we make it at any point in the third stage (*c*), we shall find only a little more residual magnetism than we should have found by making the experiment at the end of stage *b*. That part of the turning of the molecules which goes on in stage *a* contributes nothing to the residual magnetism. That part which goes on in stage *c* contributes little. But that part of the turning which goes on in stage *b* contributes very much.

In some specimens of magnetic metal we find a much

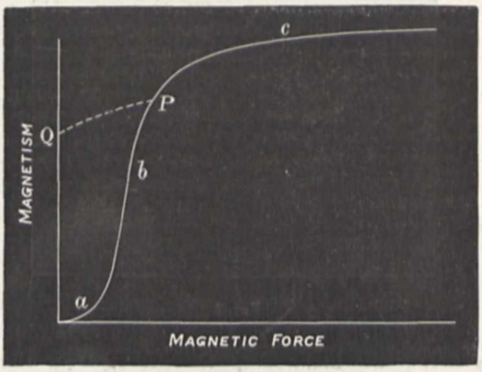

FIG. 1.

sharper separation of the three stages than in others. By applying strain in certain ways it is possible to get the stages very clearly separated. Fig. 2, a beautiful instance of that, is taken from a paper by Mr. Nagaoka—one of an able band of Japanese workers who are bidding fair to repay the debt that Japan owes for its learning to the West. It shows how a piece of nickel which is under the joint action of pull and twist becomes magnetized in a growing magnetic field. There the first stage is exceptionally prolonged, and the second stage is extraordinarily abrupt.

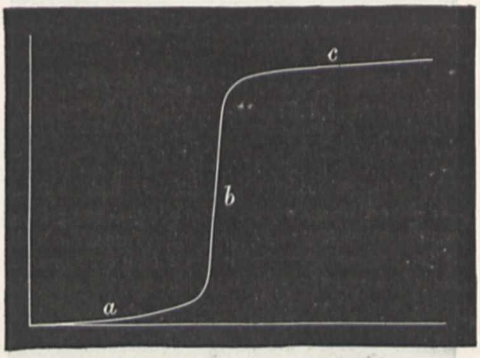

FIG. 2.

The bearing of all this on the molecular theory will be evident when we turn to these models, consisting of an assemblage of little pivoted magnets, which may be taken to represent, no doubt in a very crude way, the molecular structure of a magnetizable metal. I have here some large models, where the pivoted magnets are pieces of sheet steel, some cut into short flat bars, others into diamond shapes with pointed ends, others into shapes resembling mushrooms or umbrellas, and in these the magnetic field is produced by means of a coil of insulated wire wound on a large wooden frame below the magnets. Some of these are arranged with the pivots on a gridiron or lazy-tongs of jointed woodenbars, so that we may readily distort them, and vary the distances of the pivots from one another, to imitate some of the effects of strain in the actual solid. But to display the experiments to a large audience a lantern model will serve best. In this one the magnets are got by taking to pieces numbers of little pocket compasses. The pivots are cemented to a glass plate, through which the light passes in such a way as to project the shadows of the magnets on the screen. The magnetic force is applied by means of two coils, one on either side of the assemblage of magnets and out of the way of the light, which together produce a nearly uniform magnetic field throughout the whole group. You see this when I make manifest the

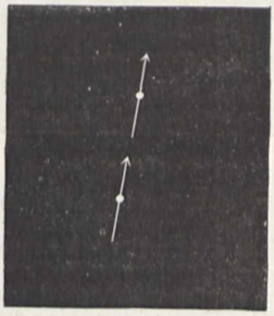

FIG. 3.

field in a well-known fashion, by dropping iron filings on the plate.

We shall first put a single pivoted magnet on the plate. So long as no field acts it is free to point anyhow—there is no direction it prefers to any other. As soon as I apply even a very weak field it responds, turning at once into the exact direction of the applied force, for there was nothing (beyond a trifling friction at the pivot) to prevent it from turning.

Now try two magnets. I have cut off the current, so that there is at present no field, but you see at once that the pair has, so to speak, a will of its own. I may shake or disturb them as I please, but they insist on taking up a position (Fig. 3) with the north end of one as close as

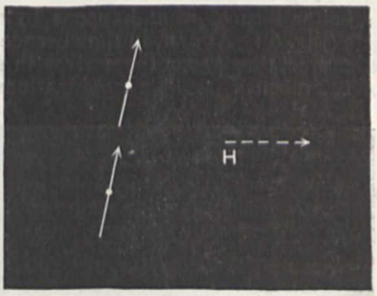

FIG. 4.

possible to the south end of the other. If disturbed they return to it: this configuration is highly stable. Watch what happens when the magnetic field acts with gradually growing strength. At first, so long as the field is weak (Fig. 4), there is but little deflection; but as the deflection increases it is evident that the stability is being lost, the state is getting more and more critical, until (Fig. 5) the tie that holds them together seems to break, and they suddenly turn, with violent swinging, into almost perfect alignment with the magnetic force H. Now I gradually remove the force, and you see that they are slow to return, but a stage comes when they swing back, and a complete removal of the force brings them into the condition with which we began (Fig. 3).

If we were to picture a piece of iron as formed of a vast number of such pairs of molecular magnets, each pair far enough from its neighbours to be practically out of reach of their magnetic influence, we might deduce many of the observed magnetic properties, but not all.

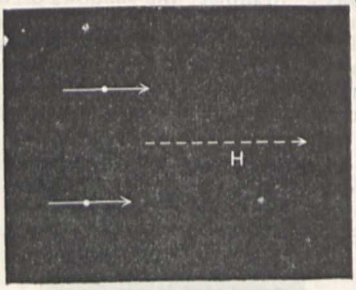

FIG. 5.

In particular, we should not be able to account for so much residual magnetism as is actually found. To get that, the molecules must make new connections when the old ones are broken; their relations are of a kind more complex than the quasi-matrimonial one which the experiment exhibits. Each molecule is a member of a larger

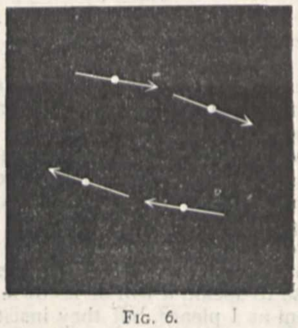

FIG. 6.

community, and has probably many neighbours close enough to affect its conduct.

We get a better idea of what happens by considering four magnets (Fig. 6). At first, in the absence of deflecting magnetic force, they group themselves in stable pairs —in one of a number of possible combinations. Then—

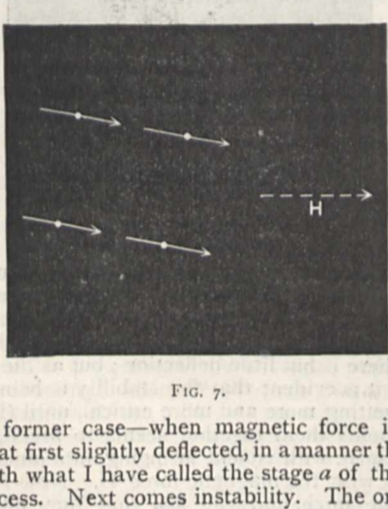

FIG. 7.

as in the former case—when magnetic force is applied, they are at first slightly deflected, in a manner that exactly tallies with what I have called the stage *a* of the magnetizing process. Next comes instability. The original ties break up, and the magnets swing violently round; but finding a new possibility of combining (Fig. 7), they take to that. Finally, as the field is further strengthened, they are drawn into perfect alignment with the applied magnetic force (Fig. 8).

We see the same three stages in a multiform group (Figs. 9, 10, 11). At first, the group, if it is shuffled by any casual disturbance, arranges itself at random in lines that give no resultant polarity (Fig. 9). A weak force produces no more than slight quasi-elastic deflections; a stronger force breaks up the old lines, and forms new ones

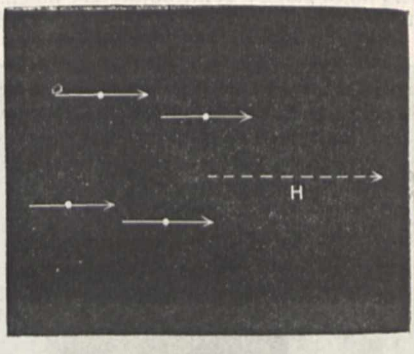

FIG. 8.

more favourably inclined to the direction of the force (Fig. 10). A very strong force brings about saturation (Fig. 11).

In an actual piece of iron there are multitudes of groups lying differently directed to begin with—perhaps also different as regards the spacing of their members. Some enter the second stage while others are still in the first, and so on. Hence, the curve of magnetization does not

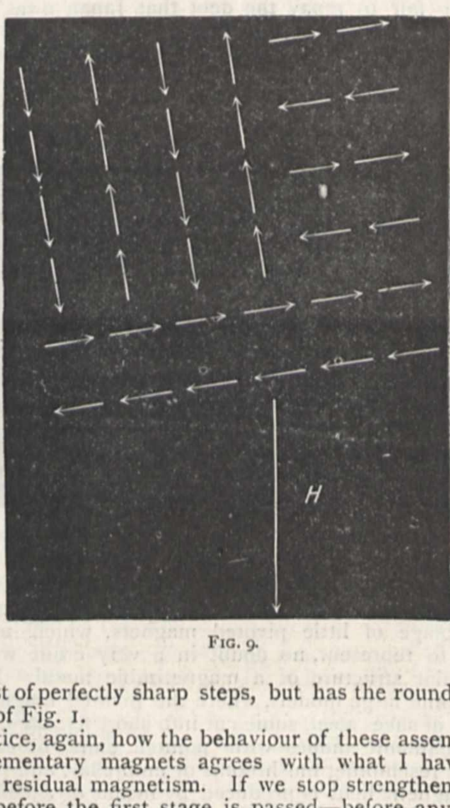

FIG. 9.

consist of perfectly sharp steps, but has the rounded outlines of Fig. 1.

Notice, again, how the behaviour of these assemblages of elementary magnets agrees with what I have said about residual magnetism. If we stop strengthening the field before the first stage is passed—before any of the magnets have become unstable and have tumbled round into new places—the small deflection simply disappears, and there is no residual effect on the configuration of the group. But if we carry the process far enough to have unstable deflections, the effects of these persist when the force is removed, for the magnets then retain the new

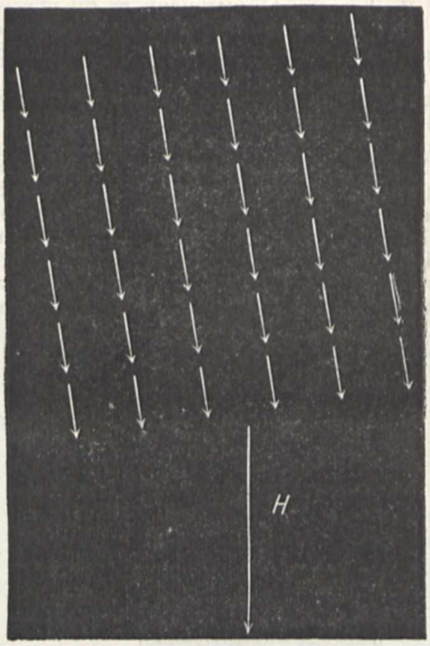

FIG. 10.

grouping into which they have fallen (Fig. 10). And again, the quasi-elastic deflections which go on during the third stage do not add to the residual magnetism.

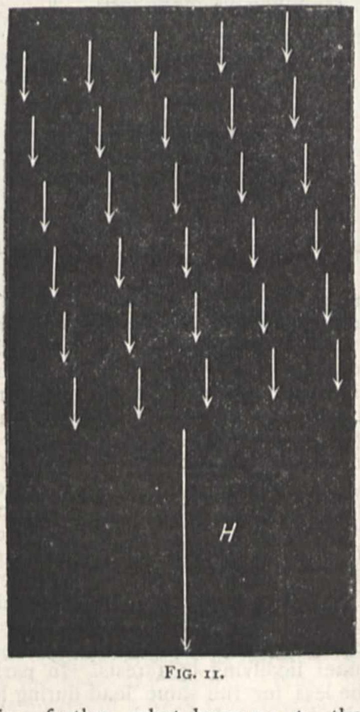

FIG. 11.

Notice, further, what happens to the group if after applying a magnetic force in one direction and removing it, I begin to apply force in the opposite direction. At first there is little reduction of the residual polarity, till a stage is reached when instability begins, and then reversal occurs with a rush. We thus find a close imitation of all the features that are actually observed when iron or any of the other magnetic metals is carried through a cyclic magnetizing process (Fig. 12). The effect of any such process is to form a *loop* in the curve which expresses the relation of the magnetism to the magnetizing force. The changes of magnetism always lag behind the changes of magnetizing force. This tendency to lag behind is called magnetic *hysteresis*.

We have a manifestation of hysteresis whenever a magnetic metal has its magnetism changed in any manner through changes in the magnetizing force, unless indeed the changes are so minute as to be confined to what I have called the first stage (*a*, Fig. 1). Residual magnetism is only a particular case of hysteresis.

Hysteresis comes in whatever be the character or cause of the magnetic change, provided it involves such deflections on the part of the molecules as make them become unstable. The unstable movements are not reversible with respect to the agent which produces them;

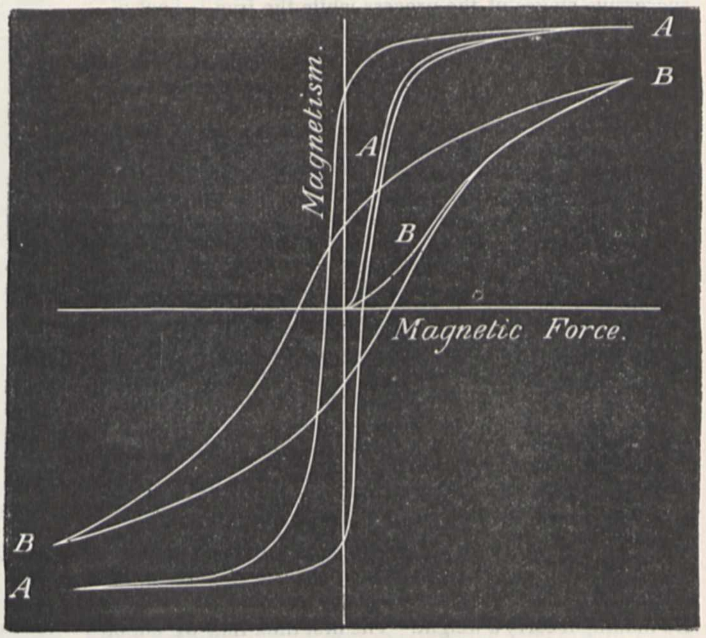

FIG. 12.—Cyclic reversal of magnetization in soft iron (AA), and in the same iron when hardened by stretching (BB).

that is to say, they are not simply undone step by step as the agent is removed.

We know, on quite independent grounds, that when the magnetism of a piece of iron or steel is reversed, or indeed cyclically altered in any way, some work is spent in performing the operation—energy is being given to the iron at one stage, and is being recovered from it at another; but when the cycle is taken as a whole, there is a net loss, or rather a waste of energy. It may be shown that this waste is proportional to the area of the loop in our diagrams. This energy is dissipated; that is to say, it is scattered and rendered useless: it takes the form of heat. The iron core of a transformer, for instance, which is having its magnetism reversed with every pulsation of the alternating current, tends to become hot for this very reason; indeed, the loss of energy which happens in it, in consequence of magnetic hysteresis, is a serious drawback to the efficiency of alternating-current systems of distributing electricity. It is the chief reason why they require much more coal to be burnt, for every unit of electricity sold, than direct-current systems require.

The molecular theory shows how this waste of energy occurs. When the molecule becomes unstable and tumbles violently over, it oscillates and sets its neighbours oscillating, until the oscillations are damped out by the eddy currents of electricity which they generate in the surrounding conducting mass. The useful work that can be got from the molecule as it falls over is less than the work that is done in replacing it during the return portion of the cycle. This is a simple mechanical deduction from the fact that the movement has unstable phases.

I cannot attempt, in a single lecture, to do more than glance at several places where the molecular theory seems to throw a flood of light on obscure and complicated facts, as soon as we recognize that the constraint of the molecules is due to their mutual action as magnets.

It has been known since the time of Gilbert that vibration greatly facilitates the process of magnetic induction. Let a piece of iron be briskly tapped while it lies in the magnetic field, and it is found to take up a large addition to its induced magnetism. Indeed, if we examine the successive stages of the process while the iron is kept vibrating by being tapped, we find that the first stage (*a*) has practically disappeared, and there is a steady and rapid growth of magnetism almost from the very first. This is intelligible enough. Vibration sets the molecular magnets oscillating, and allows them to break their primitive mutual ties and to respond to weak deflecting forces. For a similar reason, vibration should tend to reduce the residue of magnetism which is left when the magnetizing force is removed, and this, too, agrees with the results of observation.

Perhaps the most effective way to show the influence of vibration is to apply a weak magnetizing force first, before tapping. If the force is adjusted so that it nearly but not quite reaches the limit of stage (*a*), a great number of the molecular magnets are, so to speak, hovering on the verge of instability, and when the piece is tapped they go over like a house of cards, and magnetism is acquired with a rush. Tapping always has some effect of the same kind, even though there has been no special adjustment of the field.

And other things besides vibration will act in a similar way, precipitating the break-up of molecular groups when the ties are already strained. Change of temperature will sometimes do it, or the application or change of mechanical strain. Suppose, for instance, that we apply pull to an iron wire while it hangs in a weak magnetic field, by making it carry a weight. The first time that we put on the weight, the magnetism of the wire at once increases, often very greatly, in consequence of the action I have just described (Fig. 13). The molecules have been on the verge of turning, and the slight strain caused by the weight is enough to make them go. Remove the weight, and there is only a comparatively small change in the magnetism, for the greater part of the molecular turning that was done when the weight was put on is not undone when it is taken off. Reapply the weight, and you find again but little change, though there are still traces of the kind of action which the first application brought about. That is to say, there are some groups of molecules which, though they were not broken up in the first application of the weight, yield now, because they have lost the support they then obtained from neighbours that have now entered into new combinations. Indeed, this kind of action may often be traced, always diminishing in amount, during several successive applications and removals of the load (see Fig. 13), and it is only when the process of loading has been many times repeated that the magnetic change brought about by loading is just opposite to the magnetic change brought about by unloading.

Whenever, indeed, we are observing the effects of an alteration of physical condition on the magnetism of iron, we have to distinguish between the primitive effect, which is often very great and is not reversible, and the ultimate effect, which is seen only after the molecular structure has become somewhat settled through many repetitions of the process. Experiments on the effects of temperature, of strain, and so forth, have long ago shown this distinction to be exceedingly important: the molecular theory makes it perfectly intelligible.

Further, the theory makes plain another curious result of experiment. When we have loaded and unloaded the iron wire many times over, so that the effect is no longer complicated by the primitive action I have just described, we still find that the magnetic changes which occur while the load is being put on are not simply undone, step by step, while the load is being taken off. Let the whole load be divided into several parts, and you will see that the magnetism has two different values, in going up and in coming down, for one and the same intermediate value of the load. The changes of magnetism lag behind the changes of load: in other words, there is *hysteresis* in the relation of the magnetism to the load (Fig. 14). This is because some of the molecular groups are every time being broken up during the loading, and re-established during the unloading, and that, as we saw already, involves hysteresis. Consequently, too, each loading and unloading requires the expenditure of a small quantity of energy, which goes to heat the metal.

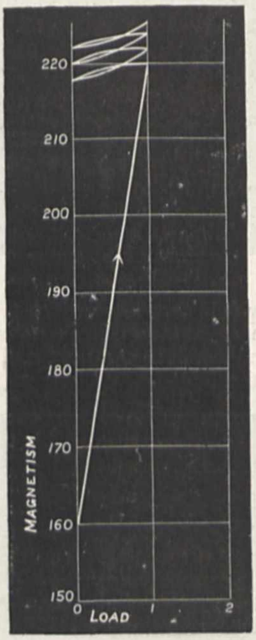

FIG. 13.—Effects of loading a soft iron wire in a constant field.

Moreover, a remarkably interesting conclusion follows. This hysteresis, and consequent dissipation of energy, will also happen though there be no magnetization of the piece as a whole: it depends on the fact that the molecules are magnets. Accordingly, we should expect to find, and experiment confirms this (see Phil. Trans., 1885, p. 614), that if the wire is loaded and unloaded, even when no magnetic field acts and there is no magnetism, its physical qualities which are changed by the load will change in a manner involving hysteresis. In particular, the length will be less for the same load during loading than during unloading, so that work may be wasted in every cycle of loads. There can be no such thing as perfect elasticity in a magnetizable metal, unless, indeed, the range of the strain is so very narrow that none of the molecules tumble through unstable states. This may have something to do with the fact, well known to engineers, that numerous repetitions of a straining action, so slight as to be safe enough in itself, have a dangerous effect on the structure of iron or steel.

Another thing on which the theory throws light is the phenomenon of time-lag in magnetization. When a piece of iron is put into a steady magnetic field, it does not take instantly all the magnetism that it will take if time be allowed. There is a gradual creeping up of the magnetism, which is most noticeable when the field is weak and when the iron is thick. If you will watch the manner in which a group of little magnets breaks up when a magnetic force is applied to it, you will see that the process is one that takes time. The first molecule to yield is some outlying one which is comparatively unattached—as we may take the surface molecules in the piece of iron

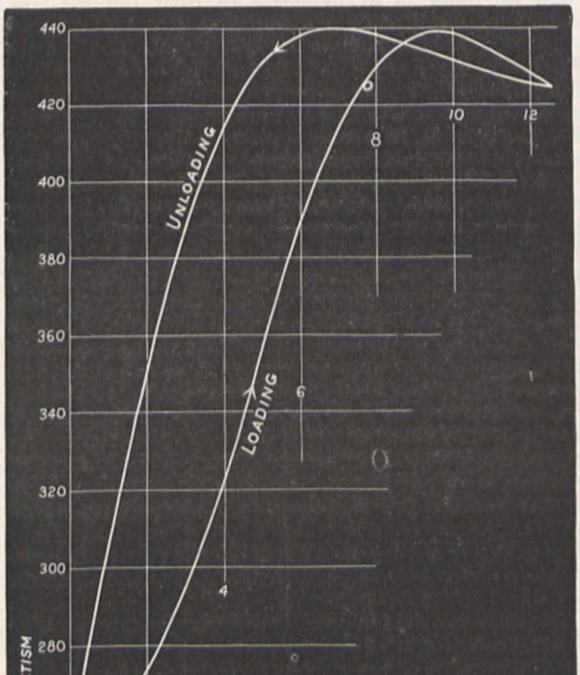

FIG. 14.—Cycle of loading and unloading.

to be. It falls over, and then its neighbours, weakened by the loss of its support, follow suit, and gradually the disturbance propagates itself from molecule to molecule throughout the group. In a very thin piece of iron—a fine wire, for instance—there are so many surface molecules, in comparison with the whole number, and consequently so many points which may become origins of disturbance, that the breaking up of the molecular communities is too soon over to allow much of this kind of lagging to be noticed.

Effects of temperature, again, may be interpreted by help of the molecular theory. When iron or nickel or cobalt is heated in a weak magnetic field, its susceptibility to magnetic induction is observed to increase, until a stage is reached, at a rather high temperature, when the magnetic quality vanishes almost suddenly and almost completely. Fig. 15, from one of Hopkinson's papers, shows what is observed as the temperature of a piece of steel is gradually raised. The sudden loss of magnetic quality occurs when the metal has become red-hot; the magnetic quality is recovered when it cools again sufficiently to cease to glow. Now, as regards the first effect—the increase of susceptibility with increase of temperature—I think that is a consequence of two independent effects of heating. The structure is expanded, so that the molecular centres lie further apart. But the freedom with which the molecules obey the direction of any applied magnetic force is increased not by that only, but perhaps even more by their being thrown into vibration. When the field is weak, heating consequently assists magnetization, sometimes very greatly, by hastening the passage from stage *a* to stage *b* of the magnetizing process. And it is at least a conjecture worth consideration whether the sudden loss of magnetic quality at a higher temperature is not due to the vibrations becoming so violent as to set the molecules spinning, when, of course, their polarity would be of no avail to produce magnetization. We know, at all events, that when the change from the magnetic to the non-magnetic state occurs, there is a profound molecular change, and heat is absorbed which is given out again when the reverse change takes place. In cooling from a red heat, the iron actually extends at the moment when this change takes place (as was shown by Gore), and so much heat is given out that (as Barrett observed) it re-

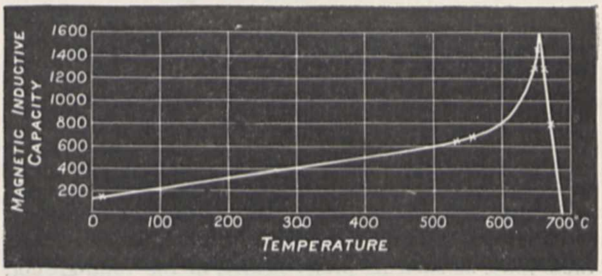

FIG. 15.—Relation of magnetic inductive capacity to temperature in hard steel (Hopkinson).

glows, becoming brightly red, though, just before the change, it had cooled so far as to be quite dull. [Experiment, exhibiting retraction and re-glow in cooling, shown by means of a long iron wire, heated to redness by the electric current.] The changes which occur in iron and steel about the temperature of redness are very complex, and I refer to this as only one possible direction in which a key to them may be sought. Perhaps the full explanation belongs as much to chemistry as to physics.

An interesting illustration of the use of these models has reached me, only to-day, from New York. In a paper just published in the *Electrical World* (reprinted in the *Electrician* for May 29, 1891), Mr. Arthur Hoopes supports the theory I have laid before you by giving curves which show the connection, experimentally found by him, between the resultant polarity of a group of little pivoted magnets and the strength of the magnetic field, when the field is applied, removed, reversed, and so on. I shall draw these curves on the screen, and rough as they are, in consequence of the limited number of magnets, you see that they succeed remarkably well in reproducing the features which we know the curves for solid iron to possess.

It may, perhaps, be fairly claimed that the models whose behaviour we have been considering have a wider application in physics than merely to elucidate magnetic processes. The molecules of bodies may have polarity which is not magnetic at all—polarity, for instance, due to static electrification—under which they group themselves in stable forms, so that energy is dissipated whenever these are broken up and rearranged. When we strain a solid body beyond its limit of elasticity, we expend work irrecoverably in overcoming, as it were, internal friction. What is this internal friction due to but the breaking and making of molecular ties? And if internal friction, why not also the surface friction which causes work to be spent when one body rubs upon another? In a highly suggestive passage of one of his writings,[1] Clerk Maxwell threw out the hint that many of the irreversible processes of physics are due to the breaking up and reconstruction of molecular groups. The models help us to realize Maxwell's notion, and, in studying them to-night, I think we may claim to have been going a step or two forward where that great leader pointed the way.

[1] "Encyc. Brit.," Art. "Constitution of Bodies."

THE SUN'S MOTION IN SPACE.

SCIENCE needed two thousand years to disentangle the earth's orbital movement from the revolutions of the other planets, and the incomparably more arduous problem of distinguishing the solar share in the confused multitude of stellar displacements first presented itself as possibly tractable little more than a century ago. In the lack for it as yet of a definite solution there is, then, no ground for surprise, but much for satisfaction in the large measure of success attending the strenuous attacks of which it has so often been made the object.

Approximately correct knowledge as to the direction and velocity of the sun's translation is indispensable to a profitable study of sidereal construction; but apart from some acquaintance with the nature of sidereal construction, it is difficult, if not impossible, of attainment. One, in fact, presupposes the other. To separate a common element of motion from the heterogeneous shiftings upon the sphere of three or four thousand stars is a task practicable only under certain conditions. To begin with, the proper motions investigated must be established with *general* exactitude. The errors inevitably affecting them must be such as pretty nearly, in the total upshot, to neutralize one another. For should they run mainly in one direction, the result will be falsified in a degree enormously disproportionate to their magnitude. The adoption, for instance, of a system of declinations as much as 1″ of arc astray, might displace to the extent of 10° north or south the point fixed upon as the apex of the sun's way (see L. Boss, *Astr. Jour.*, No. 213). Risks on this score, however, will become less formidable with the further advance of practical astronomy along a track definable as an asymptote to the curve of ideal perfection.

Besides this obstacle to be overcome, there is another which it will soon be possible to evade. Hitherto, inquiries into the solar movement have been hampered by the necessity for preliminary assumptions of some kind as to the relative distances of classes of stars. But all such assumptions, especially when applied to selected lists, are highly insecure; and any fabric reared upon them must be considered to stand upon treacherous ground. The spectrographic method, however, here fortunately comes into play. "Proper motions" are only angular velocities. They tell nothing as to the value of the perspective element they may be supposed to include, or as to the real rate of going of the bodies they are attributed to, until the size of the sphere upon which they are measured has been otherwise ascertained. But the displacements of lines in stellar spectra give directly the actual velocities relative to the earth of the observed stars. The question of their distances is, therefore, at once eliminated. Now the radial component of stellar motion is mixed up, precisely in the same way as the tangential component, with the solar movement; and since complete knowledge of it, in a sufficient number of cases, is rapidly becoming accessible, while knowledge of tangential velocity must for a long time remain partial or uncertain, the advantage of replacing the discussion of proper motions by that of motions in line of sight is obvious and immediate. And the admirable work carried on at Potsdam during the last three years will soon afford the means of doing so in the first, if only a preliminary investigation of the solar translation based upon measurements of photographed stellar spectra.

The difficulties, then, caused either by inaccuracies in star-catalogues or by ignorance of star-distances, may be overcome; but there is a third, impossible at present to be surmounted, and not without misgiving to be passed by. All inquiries upon the subject of the advance of our system through space start with an hypothesis most unlikely to be true. The method uniformly adopted in them —and no other is available—is to treat the *inherent* motions of the stars (their so-called *motus peculiares*) as pursued indifferently in all directions. The steady drift extricable from them by rules founded upon the science of probabilities is presumed to be solar motion visually transferred to them in proportions varying with their remoteness in space, and their situations on the sphere. If this presumption be in any degree baseless, the result of the inquiry is *pro tanto* falsified. Unless the deviations from the parallactic line of the stellar motions balance one another on the whole, their discussion may easily be as fruitless as that of observations tainted with systematic errors. It is scarcely, however, doubtful that law, and not chance, governs the sidereal revolutions. The point open to question is whether the workings of law may not be so exceedingly intricate as to produce a grand sum-total of results which, from the geometrical side, may justifiably be regarded as casual.

The search for evidence of a general plan in the wanderings of the stars over the face of the sky has so far proved fruitless. Local concert can be traced, but no widely-diffused preference for one direction over any other makes itself definitely felt. Some regard, nevertheless, *must* be paid by them to the plane of the Milky Way; since it is altogether incredible that the actual construction of the heavens is without dependence upon the method of their revolutions.

The apparent anomaly vanishes upon the consideration of the profundities of space and time in which the fundamental design of the sidereal universe lies buried. Its composition out of an indefinite number of partial systems is more than probable; but the inconceivable leisureliness with which their mutual relations develop renders the harmony of those relations inappreciable by short-lived terrestrial denizens. "Proper motions," if this be so, are of a subordinate kind; they are indexes simply to the mechanism of particular aggregations, and have no definable connection with the mechanism of the whole. No considerable error may then be involved in treating them, for purposes of calculation, as indifferently directed; and the elicited solar movement may genuinely represent the displacement of our system relative to its more immediate stellar environment. This is perhaps the utmost to be hoped for until sidereal astronomy has reached another stadium of progress.

Unless, indeed, effect should be given to Clerk Maxwell's suggestion for deriving the absolute longitude of the solar apex from observations of the eclipses of Jupiter's satellites (Proc. Roy. Soc., vol. xxx. p. 109). But this is far from likely. In the first place, the revolutions of the Jovian system cannot be predicted with anything like the required accuracy. In the second place, there is no certainty that the postulated phenomena have any real existence. If, however, it be safe to assume that the solar system, cutting its way through space, virtually raises an ethereal counter-current, and if it be further granted that light travels faster *with* than *against* such a current, then indeed it becomes speculatively possible, through slight alternate accelerations and retardations of eclipses taking place respectively ahead of and in the wake of the sun, to determine his absolute path in space as projected upon the ecliptic. That is to say, the longitude of the apex could be deduced together with the resolved part of the solar velocity; the latitude of the apex, as well as the component of velocity perpendicular to the plane of the ecliptic, remaining, however, unknown.

The beaten track, meanwhile, has conducted two recent inquirers to results of some interest. The chief aim of each was the detection of systematic peculiarities in the motions of stellar assemblages after the subtraction from them of their common perspective element. By varying the materials and method of analysis, Prof. Lewis Boss, Director of the Albany Observatory, hopes that corresponding variations in the upshot may betray a significant character. Thus, if stars selected on different principles give notably and consistently different results, the cause of the difference may with some show of reason be supposed to reside in specialities of movement appertaining to the several groups. Prof. Boss broke ground in this direction by investigating 284 proper motions, few of which had been similarly employed before (*Astr. Jour.*, No. 213). They were all taken from an equatorial zone 4° 20′ in breadth, with a mean declination of +3°, observed at Albany for the catalogue of the Astronomische Gesellschaft, and furnished data accordingly for a virtually independent research of a somewhat distinctive kind. It was carried out to three separate conclusions. Setting aside five stars with secular movements ranging above 100″, Prof. Boss divided the 279 left available into two sets—one of 135 stars brighter, the other of 144 stars fainter, than the eighth magnitude. The first collection gave for the goal of solar translation a point about 4° north of *α* Lyræ, in R.A. 280°, Decl. + 43°; the second, one some thirty-seven minutes of time to the west of *δ* Cygni, in R.A. 286°, Decl. + 45°. For a third and final solution, twenty-six stars moving 40″–100″ were rejected, and the remaining 253 classed in a single series. The upshot of their discussion was to shift the apex of movement to R.A. 289°, Decl. + 51°. So far as the difference from the previous pair of results is capable of interpretation, it would seem to imply a predominant set towards the north-east of the twenty-six swifter motions subsequently dismissed as prejudicial, but in truth the data employed were not accurate enough to warrant so definite an inference. The Albany proper motions, as Prof. Boss was careful to explain, depend for the most part upon the right ascensions of Bessel's and Lalande's zones, and are hence subject to large errors. Their study must be regarded as suggestive rather than decisive.

A better quality and a larger quantity of material was disposed of by the latest and perhaps the most laborious investigator of this intricate problem. M. Oscar Stumpe, of Bonn (*Astr. Nach.*, Nos. 2999, 3000) took his stars, to the number of 1054, from various quarters, if chiefly from Auwers's and Argelander's lists, critically testing, however, the movement attributed to each of not less than 16″ a century. This he fixed as the limit of secure determination, unless for stars observed with exceptional constancy and care. His discussion of them is instructive in more ways than one. Adopting, the additional computative burden imposed by it notwithstanding, Schönfeld's modification of Airy's formulæ, he introduced into his equations a fifth unknown quantity expressive of a possible stellar drift in galactic longitude. A negative result was obtained. No symptom came to light of "rotation" in the plane of the Milky Way.

M. Stumpe's intrepid industry was further shown in his disregard of customary "scamping" subterfuges. Expedients for abbreviation vainly spread their allurements; every one of his 2108 equations was separately and resolutely solved. A more important innovation was his substitution of proper motion for magnitude as a criterion of remoteness. Dividing his stars on this principle into four groups, he obtained an apex for the sun's translation corresponding to each as follows:—

Group.	Number of included stars.	Proper motion.	Apex.	
I. ...	551 ..	0″·16 to 0″·32 ...	R.A. 287°·4	Decl. + 42°
II. ...	340 ...	0·32 to 0·64 ...	,, 279·7	,, 40·5
III. ...	105 ...	0·64 to 1·28 ...	,, 287·9	,, 32·1
IV. ...	58 ...	1·28 and upwards	,, 285·2	,, 30·4

Here, again, we find a marked and progressive descent of the apex towards the equator with the increasing swiftness of the objects serving for its determination, leading to the suspicion that the most northerly may be the most genuine position, because the one least affected by stellar individualities of movement. By nearly all recent investigations, moreover, the solar *point de mire* has been placed considerably further to the east and nearer to the Milky Way, than seemed admissible to their predecessors; so that the constellation Lyra may now be said to have a stronger claim than Hercules to include it; and the necessity has almost disappeared for attributing to the solar orbit a high inclination to the medial galactic plane.

From both the Albany and the Bonn discussions, there emerged with singular clearness a highly significant relation. The mean magnitudes of the two groups into which Prof. Boss divided his 279 stars, were respectively 6·6 and 8·6, the corresponding mean proper motions 21″·9 and 20″·9. In other words, a set of stars on the whole six times brighter than another set owned a scarcely larger sum-total of apparent displacement. And that this approximate equality of movement really denoted approximate equality of mean distance was made manifest by the further circumstance that the secular journey of the sun proved to subtend nearly the same angle whichever of the groups was made the standpoint for its survey. Indeed, the fainter collection actually gave the larger angle (13″·73 as against 12″·39), and so far an indication that the stars composing it were, on an average, nearer to the earth than the much brighter ones considered apart.

A result similar in character was reached by M. Stumpe. Between the mobility of his star groups, and the values derived from them for the angular movement of the sun, the conformity proved so close as materially to strengthen the inference that apparent movement measures real distance. The mean brilliancy of his classified stars seemed, on the contrary, quite independent of their mobility. Indeed, its changes tended in an opposite direction. The mean magnitude of the slowest group was 6·0, of the swiftest 6·5, of the intermediate pair 6·7 and 6·1. And these are not isolated facts. Comparisons of the same kind, and leading to identical conclusions, were made by Prof. Eastman at Washington in 1889 (Phil. Society Bulletin, vol. xi. p. 143; Proceedings Amer. Association, 1889, p. 71).

What meaning can we attribute to them? Uncritically considered, they seem to assert two things, one reasonable, the other palpably absurd. The first—that the average angular velocity of the stars varies inversely with their distance from ourselves—few will be disposed to doubt; the second—that their average apparent lustre has nothing to do with greater or less remoteness—few will be disposed to admit. But, in order to interpret truly, well-ascertained if unexpected relationships, we must remember that the sensibly moving stars used to determine the solar translation are chosen from a multitude sensibly fixed; and that the proportion of stationary to travelling stars rises rapidly with descent down the scale of magnitude. Hence a mean struck in disregard of the zeros, is totally misleading; while the account is no sooner made exhaustive than its anomalous character becomes largely modified. Yet it does not wholly disappear. There is some warrant for it in nature. And its warrant may perhaps consist in a preponderance, among suns endowed with high *physical* speed, of small, or slightly luminous, over powerfully radiative bodies. Why this should be so, it would be futile, even by conjecture, to attempt to explain.

A. M. CLERKE.

NOTES.

THE respect in which science is held in Germany was strikingly displayed on Tuesday, when Prof. Virchow celebrated his seventieth birthday. The occasion was regarded as one of national importance, and much honour was done to the investigator who, in the course of his great career, has given a fresh impetus to so many departments of research. In the morning, congratulations were offered to him in the large hall of the Kaiserhof Hotel, Berlin. The room was crowded with professors, academicians, and men of science from all parts of Europe; and on a long table were innumerable presents, medals, diplomas, and addresses. Short speeches were delivered on behalf of a series of deputations, the first of which was headed by Dr. Bartsch, one of the chief officials of the Ministry. A deputation, consisting of the professors of the Medical Faculty of the University of Berlin, and headed by Prof. Hirsch, the Dean, was followed by another from the Berlin Academy of Science, for which Prof. von Helmholtz spoke. Dr. von Forckenbeck, the Burgomaster of Berlin, heading a deputation from the Municipality of the capital, presented Prof. Virchow with the freedom of the city, referring gratefully to all that he had done to improve the health of the community. An address and medal, sent by English scientific bodies, were presented by Dr. Simon and Mr. Horsley, and then came congratulatory addresses from the Medical Faculties of many foreign cities, including Amsterdam, Brussels, Stockholm, St. Petersburg, Moscow, Pavia, and Tokio. The Virchow gold medal, for which contributions had been sent from all sections of the medical world, was presented by Prof. Waldeyer. Frau Virchow received a silver replica, and bronze copies were given to the other members of the family and to the scientific bodies which had subscribed for the medal. In the afternoon, a second meeting was held in the large hall of the Pathological Institute, where, as the Berlin correspondent of the *Times* says, "an almost endless procession of learned bodies and other corporations, presenting gifts and addresses, defiled before Prof. Virchow." The day's proceedings lasted from 10 a.m. to 4 p.m.; but it was noted, we are glad to say, that Prof. Virchow "seemed in no way fatigued by his exertions." More speeches were delivered in the evening, when a "Commers," or reunion, of his friends and admirers was held in Kroll's Theatre.

THE ordinary general meeting of the Institution of Mechanical Engineers will be held on Wednesday evening, October 28, and Thursday evening, October 29, at 25 Great George Street, Westminster. The chair will be taken at half-past seven p.m. on each evening by the President, Mr. Joseph Tomlinson. The ballot lists for the election of new members, associates, and graduates having been previously opened by the Council, the names of those elected will be announced to the meeting. The nomination of officers for election at the next annual general meeting will take place. The following papers will be read and discussed, as far as time permits:—On some details in the construction of modern Lancashire boilers, by Mr. Samuel Boswell (Wednesday); First Report to the Alloys Research Committee, by Prof. W. C. Roberts-Austen, C.B., F.R.S. (Thursday).

THE anniversary meeting of the Mineralogical Society will be held in the apartments of the Geological Society, Burlington House, on Tuesday, November 10, at 8 p.m.

THE International Congress of Analytical Chemists and Microscopists met at Vienna on October 12 and 13. The subject discussed was the adulteration of food-stuffs.

GREAT preparations are being made for the meeting of the Australasian Association for the Advancement of Science which is to be held at Hobart, Tasmania, in January next. It is expected that the meeting will be most successful. The members of the Royal Society of Tasmania are congratulating themselves that Mr. Giffen, the eminent statistician and political economist, proposes to attend the meeting and to read a paper. His Excellency Sir R. G. C. Hamilton, who will preside, tried some time ago to secure the presence of Prof. Huxley also. Prof. Huxley replied that he had pleasant recollections of Tasmania as it was forty-three years ago, and it would have interested him very much to revisit the colony and compare the present with the past, but he regretted that the state of his health prevented him from accepting the invitation.

ONE of the last surviving pupils of Dalton died at Bolton on October 6. Mr. William B. Watson was born at Bolton in January 1812, and educated at the local grammar-school. He afterwards studied for some years under Dalton at Manchester, and became so devoted to his teacher that he was chosen to help in the nursing of Dr. Dalton during the illness following his first paralytic seizure. Mr. Watson also assisted in many of Dalton's researches, and is mentioned by name in his papers in the Philosophical Transactions on the composition of the atmosphere as "an ingenious pupil of mine, Mr. William Barnett Watson." Mr. Watson had a wonderful store of anecdotes about his old master, and used to speak with pride of the great care he took in all his work. As an instance may be mentioned the pains he took to compensate for his colour-blindness. Dalton used to say that the bloom on a maiden's cheek and the colour of a faded green table-cloth seemed to him one and the same, and that he could only distinguish between the fruit and leaves on an apple-tree by their difference in shape. Dalton had a book containing different colours of floss silk, and below these he carefully noted the names given to them by non-colour-blind people, adding what the colour appeared to him to be. Careful methods such as these enabled him generally to give an accurate description of the colour of a precipitate. Mr. Watson carried on, together with his elder brother, Mr. H. H. Watson, a very extensive practice as an analytical chemist, and was much consulted in legal and commercial cases.

THE death of Mr. Charles Smith Wilkinson, the Government Geologist of New South Wales, will be felt as a great loss, especially in his own colony. His enthusiasm in the cause of geological science, his extensive knowledge of the geological features of Eastern Australia, and his admirable personal qualities had made him greatly valued. Mr. Wilkinson was an original member of the Linnean Society of New South Wales, and president of that Society in the years 1883 and 1884. His death, which took place at the age of forty-seven, on the 26th of August, was announced to the Society on the evening of the same day.

La Nature announces the death of Prof. Edouard Lucas, who presided over the Sections of Mathematics and Astronomy at the recent meeting, at Marseilles, of the French Association for the Advancement of Science. A pile of plates fell one day after dinner while he was at Marseilles, and he happened to be struck in the cheek by a fragment of the broken earthenware. The hurt became more and more troublesome, and after his return to Paris he died of erysipelas. M. Lucas was forty-nine years of age. He was a brilliant lecturer, and the author of several valuable books, the most important of which is his "Récréations Mathématiques."

APPLICATION has been made for 20,000 square feet of space for the electrical display from Great Britain at the "World's Fair" at Chicago. *Electricity*, the new weekly journal published at Chicago, remarks that this application should "set at rest all doubts in regard to the extent of the exhibit to be made by British manufacturers of electrical apparatus."

MR. C. E. KELWAY is now showing at the Royal Naval Exhibition an invention which promises to be of great practical value. It consists of an apparatus for marine and general electrical signalling. A number of electric incandescent lamps are placed in a suitable frame, from which insulated wires are led to a key-board, similar to those used in type-writers, or compound-switch. A key is appropriated for each letter of the alphabet and for numerals. On this key being depressed the electric current is switched on to the lamps representing the corresponding letter, which is at once shown to the observer. On the pressure being removed the lights disappear, and the next letter, or numeral, is in like manner shown, the words being spelt out at a rate more quickly than by the Morse system. Mr. Kelway claims that the applications to which this invention can be put are numerous. It might, he thinks, be of great service in naval tactics, and prove invaluable for military purposes. He also points out that it would enable mercantile vessels to communicate readily with each other and with the shore.

A CORRESPONDENT asks whether there are any firms which supply magic lantern slides dealing with geological subjects.

THE marine laboratory of biology and zoology, which is to be instituted at Bergen next year, will be open to any foreign investigators who may desire to study the marine fauna of that part of Scandinavia.

THE complete list of subscribers to the memorial to Bishop Berkeley, which has just been issued, contains the names of Profs. Huxley and Tyndall, in company with the Archbishop of Dublin and a number of bishops and deans. Mr. Gladstone and Mr. Balfour meet together in the same list. The memorial is a beautiful recumbent figure by Mr. Bruce Joy, R.A., which has been placed in Cloyne Cathedral. The inscription to be placed on the monument has not yet been announced.

THE Sociedad Cientifica "Antonio Alzate," of Mexico, who have lately moved into new quarters, have just resolved to throw open their scientific library to the general public. They are appealing on this ground to all foreign professors and scientific authors to send copies of their works to the library.

THE Engineers' and Architects' Institute of Vienna have resolved to petition the Austrian Government that engineer attachés should in future be appointed to the embassies and legations in London, Berlin, Paris, St. Petersburg, Rome, Washington, and to one Oriental city to be hereafter selected.

THE Royal Horticultural Society has issued a list of fruits which might be profitably cultivated by cottagers and small farmers in this country. The list (to which are added notes on planting, pruning, and manuring) ought to be widely distributed. It contains all the information that is really necessary for the development of a most important industry.

ACCORDING to a telegram sent from San Francisco, a severe shock of earthquake was felt there on October 11, but no damage was done. At Napa, California, where a heavy shock was experienced, the chimneys were thrown to the ground, and several buildings were shattered. The State Insane Asylum is reported to have been damaged, fissures being made in the walls. The inmates were seized with panic.

WE take from *La Nature* of the 3rd inst. the following particulars respecting the destructive cyclone which visited Martinique on the 28th of August last. The curve of a Richard barograph shows that the barometer commenced to fall about 2 p.m., when it stood at 29·92 inches, while between 7 and 8 p.m. it fell from 29·72 inches to 28·70 inches. The wind at this time, too, reached its greatest violence, and continued with hurricane force for several hours, passing alternately from N.E. to South. The recovery of the barometric pressure was equally rapid, the reading being about 29·70 inches before 10 p.m. M. Sully, of Saint Pierre, writes that the lightning was constant, with varying intensity before and after the passage of the centre. The sound of the thunder was scarcely perceptible, owing to the howling of the wind and the noise caused by the falling roofs and houses. Globular lightning was seen on all sides during the hurricane; the country folks speak of globes of fire which traversed the air for several minutes, and burst about two feet above the ground. All the towns and villages were greatly damaged, the crops destroyed, and that usually verdant country presented the appearance of the depth of the most severe winter. The deaths are said to be 420 in number.

IN the review of September in the U.S. Pilot Chart, it is pointed out that the month was unusually stormy on the North Atlantic, as indicated by the storm tracks plotted on the chart. Two of these tracks, however, represent August storms, one of them being the track of the Martinique hurricane, and another the track of the hurricane that passed east of Bermuda on August 27. The Martinique hurricane, it appears, moved west-north-west along a somewhat irregular track, crossing over Puerto Rico, Turk's Island, Crooked Island, and lower Florida, finally dying out in the north-eastern Gulf. This unusual course makes it of special interest, and its failure to recurve seems to have been due, possibly, to the opposition of the Bermuda hurricane, in a manner similar to the deflection towards Vera Cruz of the Cuban hurricane of September 1888. The Bermuda hurricane appears to have originated about 300 miles S.W. of the Cape Verde Islands on August 19.

THE correspondent of the *Times* at Alexandria telegraphed on October 11 that three colossal statues, ten feet high, of rose granite, had just been found at Aboukir, a few feet below the surface. The discovery was made from indications furnished to the Government by a local investigator, Daninos Pasha. The first two represent in one group Rameses II. and Queen Hentmara seated on the same throne. This is unique among Egyptian statues. The third statue represents Rameses standing upright in military attire, a sceptre in his hand and a crown upon his head. Both bear hieroglyphic inscriptions, and both have been thrown from their pedestals face downwards. Their site is on the ancient Cape Zephyrium, near the remains of the Temple of Venus at Arsinoe. Relics of the early Christians have been found in the same locality.

WE learn from the *Brighton Herald* that a discovery full of interest to archæologists has been made in Sussex. During some excavations near the depot of the Artillery Volunteers at Southover, Lewes, the workmen uncovered as many as twenty-eight skeletons. They were all buried close to the surface, and within an area of about 130 feet by 50 feet. As there were skeletons of women as well as of men, it is concluded that the site was not that of a battle-field, but of a place of burial. A similar find was made in 1830 at Malling Hill, which is not far distant. The remains now found were accompanied by a large number of weapons and ornaments, the characteristic features of which point to the fact of their being Anglo-Saxon. The skeletons have been reinterred, but the weapons and other articles have been placed in the museum of the Sussex Archæological Society at Lewes Castle.

MR. CLEMENT L. WALKER, while carrying on geological work in South-Western New Mexico, has also been pursuing archæological researches in that most interesting region during the last two years. He proposes to publish a detailed account of his investigations, and in the meantime he briefly records some of them in the August number of the *American Naturalist*, On the east, west, and middle branches of the Gila River, in the Mogollon Mountains, there is an extremely rough, wild, and broken tract; and here, in the rugged cliffs, are found great numbers of ancient cliff-dwellings. Mr. Webster devoted considerable time to the study of these dwellings, making plans and sketches, and copying the drawings of many of the more interesting and extensive hieroglyphics painted on the rocks. One of these ancient pueblos of the cliff-dwellers is situated in a lofty cliff which forms the side of a deep, narrow cañon extending out from the west branch of the Gila. This cliff-dwellers' village is in a fine state of preservation, and consists of upwards of twenty-eight rooms. Among the relics obtained in the rooms were specimens of several kinds of cloth, all made from the fibre of the Spanish dagger, matting of bear-grass. willow-work, sandals, cords of various sizes, feather-work, a ball and large skein of twine of the same material as the cloth, human and animal bones, stone utensils, great quantities of corn-cobs, corn, squash or pumpkin rinds, seeds and stems, corn-husks, beans, gourds, pottery, braided human hair of a brown colour, &c.; and last, but by no means least, a perfectly preserved cliff-dweller mummy. This was a mummy of a small child, with soft brown hair, similar to that found braided, only finer. It was closely wrapped in a considerable amount of two varieties of coarse cloth, woven from the fibre of the Spanish dagger, then wrapped in a large nicely-woven mat of bear-grass, and tied on by cords of the same material as the cloth to a small curiously-shaped board of cotton-wood.

SOME fine caves have lately been discovered near Southport, Tasmania. At the meeting of the Royal Society of Tasmania in June, an account of them was given by Mr. Morton, who had visited them. They are situated about four miles from Ida Bay, and a fairly good road leads to them. The entrance is through a limestone formation. A strong stream flows along the floor of the chambers. The first chamber reached by Mr. Morton and those who accompanied him showed some fine stalactites, and along the floor some fine stalagmites were seen. On the lights carried by the party being extinguished, the ceiling and sides of the caves seemed studded with diamonds, an effect due to millions of glow-worms hanging to the sides of the walls and from the ceilings. Further on, several chambers were explored, each revealing grander sights. The time at disposal being limited, the party had to return after traversing a distance of about three-quarters of a mile, but from what was observed the caves evidently extended a distance of three or four miles. The only living creatures seen were the glow-worms. These caves, under proper supervision, should become, Mr. Morton thinks, one of the great attractions of the south of Tasmania.

IN the Quarterly Statement of the Palestine Exploration Fund, it is announced that the first volume of the "Survey of Eastern Palestine," by Major Conder, has been issued to subscribers. It is accompanied by a map of the portion of country surveyed, special plans, and upwards of 350 drawings of ruins, tombs, dolmens, stone circles, inscriptions, &c. It is also announced that the new map of Palestine, so long in hand, is now ready. This map represents both sides of the Jordan, and extends from Baalbek in the north, to Kadesh Barnea in the south.

MR. E. R. MORSE contributes to the October number of the *Engineering Magazine*, a periodical issued at New York, an interesting paper on marble quarrying in the United States. Within recent years the use of American marble both in cemeteries and in buildings has become very extensive. Various foreign marbles, such as the African Red, Belgium Black, and Mexican Onyx, are employed in the interior decoration of buildings; but only Italian marble can be said to come really into competition with the American product, and the importation of this stone into the United States amounts only to about one-sixth of the value of the marble produced and sold at home. The quarrying of marble is practically limited at present to Tennessee, Georgia, Maryland, New York, Massachusetts, and Vermont. Large and valuable deposits may exist elsewhere, but the expense of testing deposits is so great, and the chances that the product of new quarries may prove unsaleable are so numerous, that Mr. Morse thinks that new marble fields are not likely to be developed soon.

THE "basking shark" (*Selache maxima*, L.) is apparently no very uncommon visitor in New Zealand waters. In the new volume of the Transactions and Proceedings of the New Zealand Institute, Mr. T. F. Cheeseman, Curator of the Auckland Museum, describes a specimen, over 34 feet long, which was stranded near the mouth of the Wade River. Mr. R. H. Shakspere, of Whangaparaoa, who saw the specimen very shortly after it was stranded, has informed Mr. Cheeseman that every spring several individuals of the same species can be seen near the entrance of the Wade River, and along the shores of Whangaparaoa Peninsula. He believes that they visit these localities in search of their food, which he thinks is composed of small *Medusæ* and other pelagic organisms. They can be easily recognized from their habit of swimming on the surface of the water, a portion of the back and the huge dorsal fin being usually exposed. It is from this circumstance, taken with the fact that their motions are very often slow and sluggish, that they have received the name of the "basking shark." They are easily approached and harpooned, and on the west coast of Ireland as many as five hundred have been taken in a single season. The liver often weighs as much as two tons, yielding six to eight barrels of oil. A few years ago, when sharks' oil was of greater value than it is at present, the oil from a single full-sized specimen would often realize from £40 to £50.

AT the meeting of the Linnean Society of New South Wales, on June 29, Mr. Froggatt exhibited some living beetles (fam. *Curculionidæ*), which afford a good example of protective coloration. They were found at Wellington, N.S.W., on the trunks of Kurrajong trees (*Sterculia*), the bark of which they resemble so closely in tint and general appearance that it was quite by accident Mr. Froggatt first recognized their true character.

MESSRS. GAUTHIER-VILLARS have sent us the "Annuaire" for 1891 of the Municipal Observatory of Montsouris. It contains, as usual, a great mass of carefully selected and well arranged information. We may especially note a collection of old meteorological observations made at Paris, and the following papers: Parisian climatology, by M. Léon Descroix; chemical analysis of the air and of waters, by M. Albert Lévy; thirteenth memoir on organic dust in the air and in waters, by Dr. Miquel.

MESSRS. G. L. ENGLISH AND CO., New York, have found it necessary to issue a supplement to the catalogue of minerals which they published in June 1890. So great has been the demand for minerals that they had three collectors at work during the summer—one in Europe, another in the south-western part of the United States and in Mexico, and a third in Colorado.

THE new number of the *Journal of Anatomy and Physiology* opens with some valuable notes by Dr. R. Havelock Charles, on the craniometry of some of the outcaste tribes of the

Panjab. He presents a series of tables drawn from the measurement of fifty skulls collected by him in the comparative anatomy museum of the Medical College, Lahore. These skulls are, in Dr. Charles's opinion, from individuals of aboriginal as distinguished from Aryan progeny, with the exception of certain megacephalic examples among the group of Mohammedan male types. In these exceptional cases descent may be derived from the more recent Mohammedan invaders, who were distinct both from the Aryan possessors on the one hand, and from the dispossessed aboriginal races on the other.

THE Department of Public Instruction in New South Wales has issued a second edition of "Wattles and Wattle-Barks," by J. H. Maiden. It appears as No. 6 of the Technical Education Series. The pamphlet is intended to supply Australian farmers, tanners, merchants, and others with authentic information in regard to the value of wattles. According to the author, the demand for good wattle-bark becomes greater every year, and the supply does not cope with it. The word "wattle," we may note, has become in Australia practically synonymous with "acacia."

AN interesting experiment has been lately made by M. Chabry, of the Société de Biologie, with regard to the pressure which can be produced by electrolytic generation of gas in a closed space. While the highest pressure before realized in this way was 447 atmospheres (Gassiot), M. Chabry has succeeded in getting as high as 1200; and the experiment was broken off merely because the manometer used got cracked (without explosion). The electrolyzed liquid was a 25 per cent. soda solution. Both electrodes were of iron: one was the hollow sphere in which the gas was collected; the other an inner concentric tube. The current had a strength of $1\frac{1}{2}$ ampere, and was very constant during the experiment, which was merely one preliminary to a research in which very high pressures were desired.

THE first series of lectures given by the Sunday Lecture Society begins on Sunday afternoon, October 18, in St. George's Hall, Langham Place, at 4 p.m., when Sir James Crichton Browne, F.R.S., will lecture on "Brain Rust." Lectures will subsequently be given by Mr. Frank Kerslake, Mr. Walter L. Bicknell, Mr. W. E. Church, Prof. H. Marshall Ward, F.R.S., Mr. A. W. Clayden, and Sir Robert Ball, F.R.S.

AN important paper upon persulphates is contributed by Dr. Marshall, of Edinburgh, to the October number of the *Journal of the Chemical Society*. The anhydride of persulphuric acid, S_2O_7, was obtained by Berthelot in the year 1878, by subjecting a well-cooled mixture of sulphur dioxide and oxygen to the silent electrical discharge. He afterwards found that a substance possessing oxidizing properties, and which appeared to be persulphuric acid, was formed in solution during the electrolysis of fairly strong solutions of sulphuric acid; it appeared, in fact, to be identical with the substance obtained by dissolving his crystals of S_2O_7 in water. The anhydride does not dissolve in water without partial decomposition, a considerable proportion decomposing into sulphuric acid and oxygen, and hitherto no salts of persulphuric acid have been obtained in the solid state. Dr. Marshall has now succeeded in obtaining the potassium, ammonium, and barium salts in fine large crystals. During the course of an experiment in which an acid solution of potassium and cobalt sulphates was being electrolyzed in a divided cell, it was found that a quantity of small colourless crystals separated. A solution of these crystals in water gave only a faint precipitate with barium chloride, but on warming barium sulphate slowly separated and chlorine was evolved. The solution also liberated iodine from potassium iodide. The crystals were, in fact, potassium persulphate, KSO_4. It was next sought to prepare them from hydrogen potassium sulphate. A saturated solution of this salt was submitted to electrolysis in a similar apparatus, and at the end of two days a white crystalline deposit of potassium persulphate commenced to form. The crystals were from time to time removed until a considerable quantity of them had been accumulated. These, when recrystallized from hot water, yielded large tabular crystals, and sometimes long prisms when formed at the surface of the liquid. Analyses of pure samples yielded numbers agreeing perfectly with the formula KSO_4. From determinations of the conductivity of dilute solutions it would appear that the correct molecular formula is KSO_4 and not $K_2S_2O_8$. On ignition of the salt, oxygen and sulphuric anhydride are evolved and potassium sulphate is left. The crystals are not very soluble in water, 100 parts of water at 0° dissolving 1·77 part of KSO_4. The aqueous solution gradually decomposes, hydrogen potassium sulphate being formed and oxygen liberated. The pure freshly prepared solution is neutral to test paper. The solution yields no precipitate with any other salt by double decomposition, the persulphates of most other metals appearing to be more soluble than potassium persulphate. A solution of lead hydrate in potash yields a precipitate of lead peroxide on boiling. With silver nitrate no immediate precipitate is formed, but the liquid gradually acquires an inky appearance and after some time a black precipitate of silver peroxide, AgO, is deposited. It would appear that silver persulphate is dissolved by water. Fehling's solution gives a red precipitate of copper peroxide. Ferrous sulphate is rapidly oxidized to ferric with considerable rise of temperature. Organic colouring matters, such as litmus, are bleached. Alcohol is oxidized to aldehyde in presence of water, but absolute alcohol has no action on solid potassium persulphate. The pure crystals have a cooling saline taste, which leaves a peculiar after-taste. The impure salt evolves ozone slowly. Freshly prepared crystals have no odour, but after a time they emit a peculiar pungent odour quite different from that of ozone, and which appears to be due to persulphuric anhydride. When warmed with concentrated nitric or sulphuric acids the oxygen is liberated largely in the form of ozone. With hydrochloric acid chlorine is evolved. The ammonium salt NH_4SO_4 has been prepared in a similar manner; it crystallizes in long prisms and much resembles the potassium salt. The barium salt crystallizes in beautiful large interlocking prisms containing four molecules of water of crystallization.

THE additions to the Zoological Society's Gardens during the past week include a Macaque Monkey (*Macacus cynomolgus* ♂) from India, presented by Mr. J. Barratt Lennard; a Rhesus Monkey (*Macacus rhesus* ♀) from India, presented by Miss Corrie Chisholm; two Common Marmosets (*Hapale jacchus*) from South-east Brazil, presented by Mrs. Frederick Betts; two Bernicle Geese (*Bernicla leucopsis*), two Brent Geese (*Bernicla brenta*), European, presented by Mr. Cecil Smith; a Gamet (*Sula bassana*), British, presented by Dr. Davis; eleven Gold Pheasants (*Thaumalea picta* ♂s), two Amherst Pheasants (*Thaumalea amherstiæ* ♂ ♂), two Silver Pheasants (*Euplocamus nycthemerus* ♂ ♀) from China, a Common Pheasant (*Phasianus colchius* ♂), British, four Ruddy Sheldrakes (*Tadorna casarca*), European, presented by Mr. Edwin J. Poyser; a Common Chameleon (*Chamæleon vulgaris*) from North Africa, presented by Mr. F. Manners; a Macaque Monkey (*Macacus cynomolgus*) from India, deposited.

OUR ASTRONOMICAL COLUMN.

MEASUREMENTS OF LUNAR RADIANT HEAT.—Numerous measurements of lunar radiant heat have been made at Birr Castle Observatory by Lord Rosse and Dr. Copeland, and the results obtained have been published from time to time. During the total lunar eclipse of October 4, 1884, Dr. Otto Boeddicker, Lord Ro se's present assistant, carried out a series of observations for the purpose of testing the striking result previously arrived at by Dr. Copeland, viz., that "the maximum of heat seemed to occur somewhat before full moon." It was then found that "The heat as before diminished, and increased again nearly proportionally to the light, becoming inappreciable on reaching the limits of totality. The minimum of heat apparently fell later than that of illumination. But the most remarkable thing was that while during the short interval between the first contact with the penumbra and the commencement of total phase, all appreciable radiation vanished, between the end of total phase and the last contact with the penumbra, and even forty minutes later, the heat had not returned to the standard for full moon, being deficient by about 12 per cent." These facts are remarked upon by Lord Rosse in an introduction to a paper by Dr. Boeddicker, giving the results obtained during the lunar eclipse of January 28, 1888 (Transactions of the Royal Dublin Society, Series III., vol. iv., Part ix., 1891). The measurements of radiation were commenced about an hour before the first contact with the penumbra, and a decrease of heat seems even then to have set in. But excluding this diminution of heat exhibited by the curve connecting the observations, there is indisputable evidence that the decrease had definitely commenced about three minutes before the eclipse began, and probably fifteen minutes before. This indicates, therefore, that the terrestrial atmosphere extends to a height of not less than 190 miles, and intercepts the sun's rays before any part of the moon has entered the earth's shadow. In 1888, as in 1884, the anomaly of the heat not returning to its standard value even 1 hour 40 minutes after the last contact with the penumbra, was observed. Dr. Boeddicker enumerates the series of observations required to elucidate these interesting points, and hopes soon to publish some further results of his investigations.

TWO NEW VARIABLE STARS.—The Rev. T. E. Espin has found two new variable stars in Cygnus, viz. D.M. + 36°·3852 and D.M. + 49°·3239. They are both of a strong red colour. The first has a Type III. (Group II.) spectrum, and the second belongs to Type IV. (Group VI.).

A NEW ASTEROID.—The asteroid observed by Dr. Palisa on August 12 turns out to be Medusa (149), as was suggested by Dr. Berberich. On this account, the asteroids from (313) to (318) must be numbered from (312) to (317), and the one discovered on September 24 by Charlois will be (318).

A NEW COMET.—A bright comet was discovered on October 2, by Mr. E. E. Barnard, at Lick Observatory, in R.A. 7h. 31m. 24s., and Decl. − 27° 54′. It was moving to the south-east.

THE IRON AND STEEL INSTITUTE.

THE autumn meeting of the Iron and Steel Institute was held on Tuesday the 6th inst. and Wednesday the 7th inst., under the presidency of Sir Frederick Abel. After the excitement of last year's meeting in the United States, the gathering of last week fell rather flat. As our readers are aware, it is the custom of this Society to hold two meetings each year—the first, in the spring, being in London, and the second, in the autumn, either in the provinces or abroad. This year it was proposed that Birmingham should be the place of meeting, but the great town of the Midlands does not appear to have responded to the overtures made, and, no other invitation being forthcoming, the Council was thrown back on the metropolis. In one point, at any rate, the meeting was a success, as on Tuesday a larger number of members travelled down to Woolwich, where a visit had been arranged to the Royal Arsenal, than perhaps have ever been got together before on an excursion.

The excursions are generally the leading feature of the autumn meetings, but there was but one organized for the meeting just past—namely, that to Woolwich Arsenal. The following is a list of the papers read :—On the constitution of ordnance factories, by Dr. William Anderson, F.R.S., Director-General of Ordnance Factories; on the measuring instruments used in the proof of guns and ammunition at the Royal Arsenal, Woolwich, by Captain Holden, R.A., Proof Officer at Woolwich; on the manufacture of continuous sheets of malleable iron and steel direct from fluid metal, by Sir Henry Bessemer, F.R.S. ; on illustrations of progress in material for shipbuilding and engineering in the Royal Naval Exhibition, by W. H. White, C.B., Chief Constructor ; on the forging press, by W. D. Allen, Sheffield ; on an undescribed phenomenon in the fusion of mild steel, by F. J. R. Carulla, Derby ; on the elimination of sulphur from pig-iron by J. Massenez, of Hoerde, Germany ; on the Metallurgic Department, Sheffield Technical School, by B. H. Thwaite, Liverpool.

The first two papers were read at the Literary Institute, Woolwich. Dr. Anderson's contribution was taken first. It is a curious fact that the Director-General of Ordnance Factories, whose admirers used to claim, before he occupied his present position, that he was too scientific to be a successful business man, should have contributed what is perhaps the least scientific paper to be found within the Transactions of the Institute. The paper was what its title indicated, strictly a description of the constitution of the Royal Ordnance Factories. It told how they comprise the Laboratory, Gun Factory, and Carriage Department at Woolwich, the Gunpowder Factory at Waltham Abbey, and the Small Arms Factories at Enfield Lock and Birmingham. These establishments are, the author said, "supposed" to be worked on commercial principles. Dr. Anderson is an accurate and careful man, as has been proved by much good scientific work in the field of mechanical engineering which he has done, and there is much virtue in his "supposed." If ever a manufacturing establishment were worked with a view to profit after the manner of Woolwich Arsenal, the profits probably would be very small. The paper tells us that £400,000 is invested in stores, £557,945 in buildings, and £718,949 in machinery. By far the larger part of the work is done on the piece, or on the fellowship system. The number of hands employed is about 17,000, of which 13,000 are at Woolwich. In the financial year 1889-90, the value of completed work issued amounted to £2,259,126. The expenditure on all services, complete and incomplete, was £2,590,053, of which wages were responsible for £1,339,045, and materials for £1,005,224. The average wage earned per week per man and boy is 32*s.*, and about £19,000 a year is spent in medical attendance, which the men receive free.

Captain Holden's paper was on an interesting subject, but was far too brief to treat it in anything approaching an adequate manner. In addition to which illustrations are necessary to make clear the working of the various delicate instruments used in the measurement of the velocity of projectiles, but no wall diagrams were exhibited. It is true that some of the actual machines were shown, but these are a very poor substitute for sectional drawings, as one can see nothing but the outside. The Novez-Leurs chronoscope, Prof. Bashforth's chronograph, Schultz's revolving drum, together with the various modifications of it which have been introduced, were all briefly referred to. Most of these instruments are fairly well known, although not in general use. The Le Boulongé instrument, which is the one now universally used for determining the velocity of projectiles outside guns, was shown and its action illustrated. The author mentioned that when the Le Boulongé instrument was first introduced the highest normal muzzle velocities of guns were about 1000 feet per second. "Now," Captain Holden said, "they are double that amount ; and it is probable they will reach 3000 feet per second." As an instance of the accuracy required in instruments of this nature, the author gave the following example : "The case of a shot whose mean velocity between two screens placed 180 feet apart is 1800 feet per second. A variation of one foot above or below 1800 feet per second is represented by a decrease or increase in time of only ·0005 of a second approximately." In order to work within such narrow limits the greatest care has to be taken to eliminate all sources of error in the instrument, and the precautions taken are briefly outlined in the paper.

After the reading of these two papers the members were conducted round the Arsenal, but such official wrath was threatened against any person who wrote for printing about anything he saw that we are too frightened to make further reference to this part of the proceedings.

On the second day of the meeting the members assembled at the Institution of Civil Engineers, Sir Frederick Abel, the President, again occupying the chair. The first paper taken was a contribution by Sir Henry Bessemer, in which he described an invention of his, devised nearly half a century ago. This consisted of the rolling of steel sheets direct from the molten metal as tapped from the furnace or converter. The process is simple in the extreme, and one can only marvel that the present complicated and costly methods should have stood so long, considering that Sir Henry Bessemer's patents have long since expired, and his direct process is open to anyone to adopt. The metal, as tapped from the furnace, in place of being run into ingots, to be afterwards rolled into slabs or billets, is just poured on to the top of a pair of water-cooled rolls placed with their axes in the same horizontal plane. The rolls are caused to revolve, and the molten metal finds its way down between the space left between them, and is thus rolled out into a continuous plate or sheet; the chill received in passing through the rolls being sufficient to solidify the metal. That the process is possible Sir Henry proved over forty years ago; that it may be made commercially successful appeared to be the unanimous opinion of the many competent critics who spoke in the discussion. Under these circumstances it would seem that the only reason why there should not be a radical change in the way of manufacturing steel plates is that the process is open to every one, and, as there are no patent rights to be acquired, it may be worth no one's while to go to the initial expenses of starting a new process just to show competitors how to do the same thing.

Mr. W. H. White's paper on the shipbuilding material at the Naval Exhibition was a useful and interesting contribution, although not so exhaustive as might have been desired. It would, however, be too much to expect so important a public servant as the Director of Naval Construction to devote his time to writing treatises for technical Societies. What Mr. White has written is of interest. He points out how the work of shipbuilding has been simplified and cheapened by the steel manufacturer, who now rolls many special sections, such as Z bars, channel bars, H bars, T bulbs, and angle bulbs, thus saving a vast amount of building up and riveting in the actual construction of the ship. The increase in the size of plates, both for ship and boiler work, was also pointed out by the author. Two specimens of boiler plate are shown in the Exhibition, which are both 1¼ in. thick and respectively 42 ft. long by 6½ ft. wide, and 31 ft. long by 7½ ft. wide. Another way in which the steelmaker and founder has helped the shipbuilder is in producing complete parts of ships, such as stern frames and stems, especially the spur stems of war vessels, which necessarily have to be of massive construction. In old days, when such parts were made of wrought iron, the forging had to be machined to form the recesses or "rabbets" necessary for the attachment of plating. That was excessively costly work, and in the case of such heavy articles was most difficult to accomplish at all. With steel castings little or no machining is required. Mr. White exhibited a large hull diagram of a ram bow for a recent battle-ship. The part is made hollow, or rather recessed, and shelves are cast on to receive the plating of the decks, and the attachment of breast hooks, &c. The author also referred to the exhibits of armour plate made at the Exhibition, but the subject is too lengthy for us to go into here, excepting to say that nickel steel has been proved by test to show such good results for armour that some of the secondary armour plating for five first class battle-ships is now being made of that material.

Mr. W. D. Allen, in his paper, described a forging press, which, although it has been at work for some years at the Bessemer Works in Sheffield, is so ingenious, and so new to most people, that we shall attempt to describe it. The press has the appearance of a steam hammer, and, indeed, there is a steam cylinder at the top, just as in a hammer. The use of the steam, however, is only to raise the tup when the hydraulic pressure is released. The press consists of an anvil block below and a ram above, the work being in a vertical direction. The ram works in a hydraulic cylinder, and is carried through the top end of the latter in the shape of a stout shaft or shank, which may be described as a tail rod to the ram. Attached to this is the piston rod of the steam piston, the latter of course working in its own cylinder. The steam cylinder and hydraulic cylinder are therefore placed tandemwise, the latter being underneath. The hydraulic cylinder is supplied with water at pressure by a suitable pump, the barrel of the pump being in direct communication with the hydraulic cylinder, there being no valve of any kind between the two. If we have made our explanation clear, it will be seen that the ram will descend and ascend stroke for stroke with the pump plunger[1] (the same water flowing backwards and forwards continuously), it being remembered that the steam cylinder has always a tendency to lift the ram. Thus, upon the pump making a forward stroke, the water in its barrel is forced into the hydraulic cylinder; the ram is thus forced down, and gives the necessary squeeze to the work on the anvil. The pump plunger then starts on its return stroke, and so, by enlarging the space in the pump barrel, enables the hydraulic ram to rise and press the water out of the cylinder and back into the pump. The rising of the ram is caused by the lifting action of the steam under the piston; the latter, it will be remembered, being attached to the ram. Of course the water pressure is sufficient to overcome the steam pressure on the downward stroke. The chief use of this press is to produce work of any given thicknesses within the range of the machine. This end is attained by regulating the volume of water used. The action may be explained as follows. We will suppose, merely for simplicity sake,[1] the content of the pump barrel to be one cubic foot, and that of the hydraulic cylinder, when the ram is at the full extent of its stroke, to be two cubic feet. We will neglect the connecting pipe between the two, as that is not a variable and does not affect the principle. If there be admitted to the pump but one cubic foot of water as the plunger moves forward, it will drive all this water (omitting clearance) into the hydraulic cylinder, and the ram would therefore only descend one half its stroke. If the stroke were two feet the travel would be 12 inches, whilst there would be 12 inches of space between the anvil and the lower side of the squeezing tool on the end of the ram. Objects of 12 inches, or above 12 inches in thickness, could therefore be forged. If, however, an article 6 inches thick had to be worked, another half cubic foot of water would have to be admitted. As the pump barrel would only accommodate one cubic foot of water, the extra half cubic foot would remain permanently in the hydraulic cylinder, and the ram would therefore not go, by six inches, to the top of its stroke; in other words, the traverse of the ram would be carried six inches nearer the anvil. It will be remembered that the upward movement of the ram is effected by the steam cylinder, which is powerful enough to lift the dead weight of the ram, but is overcome by the hydraulic pressure. It will be seen that by regulating the volume of water in the machine, the ram—although always making the same length of stroke—can be kept working at any given distance from the anvil: the ram and pump-plunger making stroke for stroke as the water flows backwards and forwards between the barrel of the pump and hydraulic cylinder. The device is no less important than ingenious. In ordinary forging, reliance has to be placed for accuracy of work on the skill of the workman. It is surprising how near perfection a good forgeman will arrive by constant practice. Such men are necessarily scarce, and as a consequence very highly paid, but even the nearest approximation of eye and hastily applied callipers, with the chance of getting a little too much work on at the last minute, cannot equal the absolutely correct results of this automatic system. There is a very ingenious valve for regulating the admission of water to fine gradations, so as to get work accurately to gauge, but we have, perhaps, given enough description of mechanism for one article.

Mr. Carulla's paper was interesting and suggestive. He was engaged in melting Bessemer scrap in pots when a crucible gave way in the furnace just as fusion was nearly complete, the greater part of the contents flowing out into the fire. The melter was just bringing the crucible out, and, instead of finding an empty broken crucible in the tongs, he discovered a number of shells corresponding in shape with the pieces originally charged, but quite hollow. This was Mr. Carulla's unaccounted for phenomenon, upon which he invited an explanation. This discussion was not satisfactory, and it was evident that those who spoke had not prepared their ideas. This was not the fault of the speakers, but of the way in which the business of these meetings is carried on. The remark applies not only to the Iron and Steel Institute, but to most of the technical Societies of the same class. When a meeting is held, a mass of papers are brought forward and read more or less hurriedly, and members get up to make such remarks as may occur to them on the spur of the moment. It is needless to point out that no satisfactory discussion of matters involving scientific principles can be carried on in this way. Mr. Carulla's paper is, as we have said, suggestive, and a complete explanation of the facts he states would doubtless lead to most important discoveries in

[1] There are actually two plungers, the pump being of the duplex type; but this is a detail which does not affect the principle.

[1] The press ram makes a stroke of 2½ inches, and its diameter is 30 inches. The total pressure at 3 tons per square inch would be 1700 tons.

metallurgical science. In such cases as this we think it would be wise to read the paper and then postpone discussion until the next meeting; or, by preference, to have the paper printed in the Journal of Proceedings, and at a meeting subsequent to its appearance call for discussion. It would appear evident that the interior of the pieces of scrap had a lower melting-point than the exterior parts which formed the shells obtained, and the explanation of the variation in melting-point was the point requiring consideration. Liquation of the elements is naturally the first suggestion, but this only shifts the uncertainty, for liquation is itself an obscure matter. Mr. Snelus would explain the matter by decarbonization at the surface, which would render the interior parts more easily fusible. He had, in raking out a furnace, found pigs of which only the outer skin remained as metal, the case thus formed being filled with graphitic carbon. Mr. Galbraith attributed the phenomenon to the surface of the metal pieces having absorbed an infusible oxide when at a high temperature. There was, however, more in the circumstances described than the meeting was prepared to explain off hand, and it would be well if the discussion could be reopened at the spring meeting or brought on again by another paper.

The contribution of Mr. Massenez was in many respects the most valuable of the meeting. It is a pleasing thing to see a foreign steelmaker putting his experience so unreservedly at the disposal of his English fellow-workers, and the thanks of the Institute are doubly due to the author for his valuable and practical paper. There is also an economic lesson in this matter, for the apparatus described owed its introduction to the German colliers' great strike of two years ago. Since then there has not only been a diminution in the amount of coal wrought, but the quality has also fallen off, so that the proportion of sulphur in the coal has much increased. This necessitated a desulphurization process, the method of which forms the subject of the paper. Manganiferous molten pig, poor in sulphur, is added to sulphuretted pig iron, poor in manganese; the result being that the metal is desulphurized, and a manganese sulphide slag is formed. The mixer in which the process is carried on is a large vessel in appearance, to judge by the drawings shown, like a converter. The apparatus in use at Hoerde will hold seventy tons of molten pig, but it has been shown that a vessel of about twice the size would be advisable. Details of the working are given by the author, and will be of great use to steelmakers working with phosphoric pig. In the discussion which followed several speakers bore testimony to the value of the invention, Sir Lowthian Bell intimating that a saving of 2*s.* 4*d.* per ton could be made by this method over the process of re-melting pig in the cupola; a step which has to be taken when it is desirable to combine the product of different blast furnaces. In the large mixer, metal from two or more furnaces can be brought together.

The only remaining paper was a contribution by Mr. B. Thwaite, in which particulars were given of the metallurgical department of the Sheffield Technical School, which was read in brief abstract by one of the clerical staff; after which the meeting was brought to a conclusion by the usual votes of thanks.

CARL WILHELM VON NÄGELI.

THE death of Carl Wilhelm von Nägeli, on May 10, 1891, removes the last survivor of that distinguished group of botanists who, side by side with zoologists such as Schwann and Kölliker, laid, half a century ago, the foundations of modern histology. The career of Nägeli is of special interest for the history of botany. During a period of fifty years he held a leading position in the advance of the science; and, while his activity began in the early days of Schleiden's predominance, his most recent work is in touch with those latest developments of biology which are connected with the name of Weismann. His work reached every side of the science. Systematic botany, morphology, anatomy, chemical and physical physiology, the theory of heredity and descent, as well as histology, all bear lasting traces of his influence.

Nägeli was born on March 27, 1817, at Kilchberg, near Zürich, and was the son of a country doctor. As a child he was devoted to books, but he soon showed a taste for natural history, which appears to have been in some degree inspired by his sister. His education as a boy was begun at a private school, of which his father was one of the founders, and was completed at the Zürich Gymnasium, where he did well. He then matriculated at the recently-established University of Zürich, with the view of studying medicine. As a student, he is said to have been strongly influenced by the "Naturphilosophie," as taught by Oken. He soon lost his taste for medical studies, and, owing to his mother's influence, was allowed to migrate to Geneva, where he devoted himself to the study of botany under De Candolle.

Nägeli took his doctor's degree at Zürich in 1840; his dissertation on the Swiss species of *Cirsium* was dedicated to Oswald Heer, and was his first contribution to that minute investigation of species which formed so characteristic a part of his life's work.

Subsequently Nägeli spent a short time at Berlin, studying, among other things, the philosophy of Hegel. A metaphysical tendency marks his writings all through life, and indeed favourably distinguishes his work from that of many less cultivated scientific writers; but Nägeli, in one of his later papers, expressly denies that he was ever himself an Hegelian.

Nägeli's next migration was to Jena, and here he came under the influence of Schleiden, by whom he was initiated into microscopic work. It was not long before the association of these two great men bore fruit. In 1844 appeared the first number of the *Zeitschrift für Wissenschaftliche Botanik* under the editorship of Schleiden and Nägeli. The connection of the former with the new venture was only a nominal one, and, indeed, all the papers but two are the work of Nägeli himself. The influence of Schleiden however, is manifest throughout, sometimes in an injurious degree, though the independence of Nägeli gradually asserted itself. To this brilliant, though short-lived publication we shall return presently. In 1845 Nägeli married, and on his wedding tour he spent a long time on the south-west coast of England, and there collected much material for his important work on "Die neueren Algen-systeme," published in 1847.

On his return to the Continent he became a *Privatdocent* at Zürich and lecturer at the veterinary school, and soon afterwards he was appointed Professor Extraordinarius. In 1850 his association with Cramer, so fruitful of good work, began. His colleague says of this time: "Es war eine schöne zeit! da wurden nicht bloss Staubfäden gezählt und Blattformen beschrieben; es ging in die Tiefe, ans Mark des Lebens!" It was the microscopic practical work with Nägeli which made the deepest impression on his distinguished pupil; his lectures, though clear and full of matter, do not appear to have been specially brilliant, but he possessed the highest qualification of a teacher in being himself a great maker of knowledge.

After declining a "call" to Giessen, Nägeli in 1852 became Professor at Freiburg im Breisgau, where most of the work was done for the "Pflanzenphysiologische Untersuchungen," published in conjunction with Cramer in 1855–58. In 1855 Nägeli accepted the post of Professor of General Botany in the new Polytechnic at Zürich; his work at this time was hindered by the temporary failure of his eyesight, owing to too much microscopic work.

In 1857 Nägeli was summoned to the Professorship of Botany at Münich, where King Maximilian II. was striving to render his capital as distinguished in science as it already was in art. This post Nägeli continued to hold to the time of his death. At first somewhat distracted from his original work by practical duties in connection with the organization of the institute and gardens, Nägeli soon resumed his proper activity, and continued for thirty years more to produce a magnificent series of researches on the most varied subjects. Unfortunately, Nägeli's work was excessive, and from the age of sixty onwards, his health began to suffer, so that he was ultimately compelled to give up teaching. An attack of influenza during the epidemic of 1889-90 seriously shattered his already failing strength, and from the effects of this he never completely recovered. He lived long enough to celebrate in great honour the jubilee of his doctor's degree, and thus to look back on half a century of continuous work for the advancement of science, a retrospect such as few savants can have enjoyed.[1]

Without attempting to give an adequate account of Nägeli's scientific work, a task which would far exceed both the limits of this article and the powers of the writer, some idea may be given of the salient points in his career as an investigator.

Nägeli's first histological paper, so far as we are aware, is on the development of pollen (1841). This already marks a de-

[1] The details of Nägeli's life are taken from the funeral address delivered by his colleague, Prof. Cramer, and published in the *Neue Zürcher Zeitung* for May 16, 1891.

cided advance on Schleiden's theory of free-cell formation, for Nägeli maintains that the special mother-cells are not formed directly around a cytoblast (nucleus) but around the whole granular contents, in the middle of which a free cytoblast lies. It was long, however, before Nägeli completely freed himself from the influence of Schleiden's histological theories. It is interesting that in this paper he described and clearly figured the two nuclei in the pollen-grain of an Œnothera, though he did not know that this was a constant phenomenon. The importance of this observation was not appreciated until Elfving, Strasburger, and Guignard, investigated the subject in our own day.

Nägeli's "Botanische Beiträge" contributed to the volume of *Linnæa* for 1842, include some important papers. In those on the development of stomata and on cell-formation in the root-apex, he endeavoured to reconcile his own accurate observations with Schleidenian theories, and was thus led to oppose Unger, who had already recognized that vegetative cell-formation is a process of division. A paper on Fungi in the interior of cells is interesting, because the existence of such endophytic forms was at that time regarded as establishing a presumption in favour of spontaneous generation.

The *Zeitschrift für Wissenschaftliche Botanik*, 1844–46, is a very remarkable publication. It never got beyond its first volume, but it may be doubted whether any book of its size has been more important for the progress of the science. Nägeli's introductory paper, "Ueber die gegenwärtige Aufgabe der Naturgeschichte, insbesondere der Botanik," is very metaphysical in tone, and is not free from a certain youthful pedantry. Great stress is laid on the absolute difference of species—a conception which, as Nägeli tells us in one of his later works, did not prevent his believing even then in the origin of species by descent. The study of development is treated as a philosophical necessity, and anatomy, or the study of *mature* structure, is denied to be a science. This is perfectly just; no one did more for anatomy than Nägeli himself, but he recognized that it only becomes scientific in union with development and physiology. He further insists that the knowledge of development as a whole is the only sound basis for classification—a principle which still remains to be carried out. The highest importance is attached to the cell theory, which was expected to do as much for botany and zoology as mathematics had done for physics, or atomic formulæ for chemistry—an expectation which cannot be regarded as unjustified. Nägeli severely criticized the theories then current, according to which cell-formation is a process of crystallization. Some of the most doubtful of his own later generalizations, however, were affected by the same source of error—namely, too great eagerness to find a simple physical explanation for biological phenomena.

Nägeli, in this paper, devotes much space to the distinctions between animals and plants. He decisively rejects the idea of a transition between the two kingdoms, on the ground that this would contradict the "Absolutheit der Begriffe"—an argument which now seems strangely out of place in natural science.

The whole paper is of great interest as showing the point of view from which biological questions were regarded at that time by a brilliant and philosophical naturalist just entering on his life's work.

The two papers in the *Zeitschrift*, on the nuclei, formation and growth of vegetable cells (1844 and 1846), are of the greatest importance to histology, finally establishing the constant occurrence of cell-division as the one mode of vegetative cell-formation. This conclusion was only reached in its completeness in the second of the two papers. Although Unger's and Mohl's views of the details of the process were in some respects the more correct, still Nägeli established the main facts of the division of the nucleus and of the cell on a broad basis of observation. These papers, as well as one on the utricular structures in the contents of cells (nuclei, nucleoli, chlorophyll granules, &c.) were translated by Henfrey for the Ray Society, to the great benefit of English students, as the writer of this article can testify.

In the same journal there are several algological papers, the most important of which is the complete and admirable account of *Caulerpa prolifera*, the extraordinary histological structure of which and its relationship to the other Siphoneæ Nägeli already thoroughly understood. It is interesting that in this paper he describes both the cell-wall and the cellulose rods as growing by apposition, a view to which we have now returned, owing to the observations of Strasburger and Noll, in opposition to Nägeli's own later theory of intussusception propounded in 1858.

The paper on *Delesseria hypoglossum* contains an elaborate account of the cell-divisions by which the thallus is built up. Nägeli here characteristically attributes great importance to the introduction of ideas of absolute mathematical form into physiology and systematic botany.

The discovery of spermatozoids in the Ferns is one of the most important recorded in this volume. The essential points in the structure and development of the antheridia are described rightly, and the movements of the spermatozoids very accurately traced. Nägeli calls attention to the nuclear reactions of the substance of the spermatozoids. He demonstrates the homology of these bodies with those of the mosses and Chara and of animals. Nägeli was at that time necessarily completely in the dark as to the relation of the spermatozoids to spore formation, for the archegonia and the process of fertilization were first discovered by Suminski four years later.

Among other papers of fundamental importance may be mentioned that on the growth of mosses, in which the apical cell-divisions and the development of the protonema are clearly made out; that on the growth of the stem in vascular plants, a work which laid the foundation of our knowledge of the distribution of vascular bundles, and that on the reproduction of the Rhizocarps. This last is especially interesting. It is directed, though very cautiously, against the Schleidenian theory of fertilization as applied to these plants. It is singular how this theory, according to which the end of the pollen-tube, after penetrating the embryo-sac, itself became the embryo, took possession of the minds of botanists at that time, and led sometimes to the strangest confusions, sometimes to a chance recognition of homologies, which could only be legitimately proved at a later period of research. In the case of the Rhizocarps, the Schleidenian theory assumed that these plants were really Phanerogams. Hence we find that he and Nägeli agree in calling their microspores pollen-grains, their microsporangia anthers, their macrospores embryo-sacs, and their macrosporangia ovules, a terminology which very nearly expresses our present view of their homologies as established by Hofmeister. Nägeli discovered the spermatozoids of these plants as well as the prothallus and archegonia, but he shows the greatest reserve in correcting Schleiden's extraordinary mistakes.

It is worth remarking that at this early period the homology of pollen-grains with spores was generally admitted, and at first we wonder how this true result could have been arrived at so prematurely. Here again the Schleidenian theory affords the explanation. The pollen-grain was regarded as a spore, which on germination produced the embryo-plant, not as do the spores of Cryptogams in the open air, but within the embryo-sac of the ovule. This conclusion was of course strengthened by a more legitimate argument drawn from a comparison of the mode of origin of pollen-grains and spores.

A less fortunate result of the same theory appears in a paper in the *Zeitschrift*, "Ueber das Wachstum und den Begriff des Blattes." Nägeli here erroneously attributes to the stem and its branches an endogenous origin. That this holds good for the *primary* axis, he proves by stating that it is derived from the pollen-grain, which itself arises endogenously within the anther!

We have dwelt long on this *Zeitschrift*, as it affords a remarkable insight into the state of botanical questions during the earlier part of the most brilliant period of progress which the science has known. The very name, *Journal for "Scientific" Botany*, is characteristic, expressing the somewhat arrogant claims of the enthusiastic naturalists of the new school of that day.

The next period in Nägeli's career is marked by the publication of two important algological works: "Die neueren Algensysteme und Versuch zur Begründung eines eigenen Systems der Algen und Florideen," 1847, and "Gattungen einzelliger Algen," 1849. It cannot be said that Nägeli was altogether happy in his generalizations on algological subjects, though his special work was often of the greatest value. At that time he included the Lichens among the Algæ and excluded the Florideæ. The Algæ in his sense were distinguished from the Fungi, not only by the presence of chlorophyll and starch, but also by the absence of spontaneous generation, while they differed from the Florideæ and all the higher plants in being destitute of sex. The Florideæ, on the other hand, he regarded as sexual and as closely allied to the Mosses. He recognized their antheridia as the male organs, but regarded the tetraspores as the product of a female organ.

on account of their superficial resemblance to the spore-tetrads of the higher Cryptogams. The carpospores, which are the real sexual products, he regarded as gemmæ like those of *Marchantia*, with the *cups* of which he compared the cystocarps. Such views were excusable at that time, but Nägeli, as we shall see, adhered to them later on with excessive pertinacity.

Nägeli was perfectly acquainted with the conjugation of Desmids and Zygnemaceæ and imperfectly with the fertilization of Vaucheria, but he imagined that these processes were too inconstant to be regarded as sexual.

Nägeli was at that time much more successful in dealing with the vegetative organs of the Algæ, and he rightly protested against the generalization current down to our own day, that all Algae are destitute of leaves.

His conviction that the Algæ are without exception sexless led him in 1849 to reject Decaisne and Thuret's discovery of the spermatozoids of Fucus, which he regarded as spores. Of his later algological papers, the most important is that on the Ceramiaceæ, published in 1861. In this the procarpia and trichogynes, the true female organs, are described and accurately figured; but Nägeli failed to recognize their true nature, and still maintained his old view of the sexuality of the tetraspores. The whole credit of the discovery of the real state of the case thus belongs to the French botanists Thuret and Bornet.

The "Pflanzenphysiologische Untersuchungen" of Nägeli and Cramer (1855–8) contain among other papers of importance Nägeli's huge work on starch grains (about 600 quarto pages!), which is of great general value as embodying his views on the growth of starch and cell-wall by intussusception and on the molecular structure of organized bodies. For many years this micellar theory, as it was afterwards called, was regarded as Nägeli's greatest achievement. Sachs, in 1875, said in his "History of Botany": "Nägeli's molecular theory is the first successful attempt to apply mechanico-physical considerations to the explanation of the phenomena of organic life." More recent research has shown that this attempt, like its predecessors, was premature, and though Nägeli's ingenious and carefully elaborated hypotheses must still arouse our admiration, we can scarcely now regard them as having added much to our knowledge either of the growth or structure of organized bodies. The book on "Starch Grains," however, quite apart from theoretical considerations, will always remain a marvellous monument of research. It contains a vast mass of systematic and descriptive matter in addition to the speculations which have made it famous. The micellar theory was further developed in subsequent papers "on the behaviour of polarized light towards vegetable organisms" (1862); "on crystalloid protein bodies" (1862); and "on the internal structure of vegetable cell-membranes" (1864). It is presented in its perfected form in the important work on the microscope, published by Nägeli and Schwendener in 1877.

The papers in the "Physiologische Untersuchungen" bear the name of Nägeli or of Cramer respectively, but it appears that they mutually assisted each other throughout; hence it is not out of place to mention here Cramer's fine researches on the apical growth of Equisetum, which to this day serve as a model (rarely approached) for all such investigations.

No sooner were these investigations with Cramer completed than another great undertaking was commenced in the publication of the "Beiträge zur Wissenschaftlichen Botanik" (1858–68). This began with the great paper "On the Growth of Stem and Root in Vascular Plants and on the Arrangement of the Vascular Bundles." This is the most important of Nägeli's purely anatomical works, and is of the greatest permanent value. It is not too much to say that the bulk of our knowledge of the distribution of vascular tissues in plants still depends on this work. Other valuable papers in the "Beiträge" are those on the use of the polarizing microscope, on the growth in thickness of the Sapindaceæ (another ideal pattern of anatomical research), and on the origin and growth of roots, in which last Leitgeb cooperated. Until the quite recent work of Van Tieghem and Douliot, this was undoubtedly the most important investigation on the subject.

Among Nägeli's later works there are two which have had a lasting influence on our views as to the biology and physiology of the simplest plants. In "Die niederen Pilze" (1877) he treats of moulds, yeasts, and bacteria in relation to infectious diseases and hygiene. In this work an excessive scepticism is displayed as to the existence of definite species among the lowest organisms, such as bacteria. There is no longer any doubt that species are neither more nor less distinct among these simple beings than among the higher plants, but Nägeli did a real service in showing that each of these species may appear in a number of morphologically and physiologically different forms.

Nägeli's "Theorie der Gährung" (1879) demonstrated the relation between the processes of fermentation and respiration, and established the modern view of fermentation, according to which, to use the words of Prof. Vines, "living protoplasm, besides undergoing decomposition itself, can induce decomposition in certain substances which are brought within the sphere of its influence."

It remains to consider briefly an aspect of Nägeli's work, which is from some points of view the most interesting of all—namely, his relation to the theory of descent. The elaborate observations on variable species, especially in the genus *Hieracium*, which Nägeli carried on throughout his whole life, side by side with his histological and physiological work, specially qualified him to take up an independent position with reference to the problems of evolution.

In his paper "Die Entstehung und Begriff der naturhistorischen Art" (1865), Nägeli for the first time discusses this question in the light of Darwin's work. His belief, however, in the origin of species by descent was no new thing, but had been tacitly held by him throughout his whole scientific career, and had been definitely expressed in his paper on individuality in Nature, published in 1856. In his work of 1865 he gave an admirably clear exposition of natural selection, but was unable to accept it as affording a sufficient explanation of evolution. He believed that variation has a definite direction, always tending towards the greater complexity and perfection of the organism (Vervollkommnungstheorie). On this view the development of the race, like that of the individual, has a definite course assigned to it beforehand. He protests that there is nothing supernatural involved in this doctrine, and that it does not necessarily require *sudden* transformations. On this latter question, however, he speaks very uncertainly, and states that transitions between certain morphological types appear to be unthinkable and impossible. One seems to catch here an echo of his older teaching about the "Absolutheit der Begriffe."

The perfecting process, he says, knows no rest; hence all plants would have become Phanerogams by this time were it not that spontaneous generation takes place at all periods. Thus the flowering plants of our own day have, on this view, the longest family history, and trace their descent from the first-formed "Urzellen," while the vascular cryptogams had a somewhat later origin, and have, consequently, not had time to advance so far, the mosses again arose more recently still, and so on with all the groups of plants. According to this singular hypothesis, there is no actual blood relationship between the higher and lower forms of any one epoch. They have had a similar but not a common origin. This remarkable, but, as it seems to us, retrogressive theory was maintained by Nägeli to the close of his career.

But, whatever view may be taken of this speculation, it must be admitted that Nägeli saw clearly the great fact—since brought home to us by the works of Weismann and his school—that the causes of variability are internal to the organism. This important doctrine, based on original experiments and observations, is maintained in a paper entitled "Ueber den Einfluss äusserer Verhältnisse auf die Varietätenbildung im Pflanzenreiche" (1865). He shows that "the formation of the more or less constant varieties or races is not the consequence and the expression of external agencies, but is determined by internal causes"; while the modifications directly produced by external influences are inconstant, and do not give rise to varieties. We think it must be allowed that, on this essential point, Nägeli was at that time somewhat in advance of Darwin himself.

Other works of that period deal with the laws affecting the distribution of species, and with the phenomena of hybridization. In the "Theorie der Bastardbildung" (1866) the peculiarities of hybrids are explained as due to the favourable or unfavourable changes produced by crossing, in the internal coadaptation of the organs of the offspring.

A paper on the social origin of new species (1872) results in the conclusion that groups of new forms are likely to arise simultaneously, rather than isolated new species.

Finally, something must be said of the great work published in 1884, "Die mechanisch-physiologische Theorie der Abstammungslehre," which states at great length Nägeli's final conclusions as to evolution and heredity. The fundamental idea of this weighty work is the conception of the Idioplasm, namely, of a definite portion of the general protoplasm, to which alone is committed the transmission of hereditary characters. This idea, as Weismann points out, is a fruitful one, and will live, and is indeed incorporated in all recent theories of heredity. Nägeli's speculations, however, as to the details of the distribution and molecular structure of this idioplasm are of much more doubtful value, and rest on no firm basis of actual observation.

Nägeli rightly argues that the character of the fertilized egg must be determined by a minute amount of idioplasm and not by the cytoplasm generally, because the characters of the male and female parent are on the average equally represented in the offspring in spite of the enormous difference in the bulk of the cytoplasm of spermatozoid and ovum.

It was only, however, after the idioplasm had been identified by Weismann and Strasburger with a definite constituent of the nucleus that the theory acquired a positive basis.

Nägeli in the "Abstammungslehre" points out that fertilization can only consist in the direct union of solid idioplasmic bodies, and thus on theoretical grounds arrives at a conclusion which has been fully confirmed by the observations of Van Beneden, Strasburger, and Guignard. He also shows that while in the higher organisms idioplasm alone is necessarily transmitted from parents to offspring, in the increase of the lower plants and animals by division, the descendants acquire a share of the nutritive protoplasm also. Hence in the latter the conditions of culture may directly affect the descendants, as Nageli found in his observations on bacteria. These views are in essential agreement with those of Prof. Weismann on the continuity of the germ-plasm, as brought forward a year later, though on other points there is a wide divergence of opinion.

Nägeli insists in his preface to this book, that the subject of heredity can only be authoritatively treated by a physiologist, and he no doubt regarded his micellar theories as an important contribution to the question. In this his view is somewhat one-sided, and as a matter of fact all recent advance in our knowledge of the essential points in reproduction has come from the morphological side.

Nägeli's attitude towards the question of spontaneous generation is interesting. In his early days he had no doubts as to the spontaneous origin of many Fungi, and thought that this could be experimentally demonstrated. In 1865 he gave up the experimental evidence, but believed in the origin *de novo* at all epochs of simple vegetable cells. In the "Abstammungslehre" he still maintains that spontaneous generation is constantly in progress, but no longer holds that even the lowest known organisms can arise in this way. His supposed primitive living things (*Probien*) are as much more simple than bacteria, as these are more simple than the highest animals or plants.

As regards the causes of evolution, Nägeli in his great work appears to limit the field of natural selection even more narrowly than in his earlier essays. Its function, according to his later views, consists in the separation and definition of races by the elimination of ill-adapted forms, rather than in determining the origin of the races themselves. In a brilliant illustration he pictures natural selection as pruning the phylogenetic tree, though powerless to cause the putting forth of new branches. He still regards evolution as a necessary progress towards perfection determined by the constitution of the organism itself, and more especially of its idioplasm.

This view is only needed if we assume with Nägeli the existence of purely morphological characters—of characters, that is, which are not, and never have been, of the nature of adaptations. It appears to us to have been sufficiently shown by Prof. Weismann and others that the existence of such characters is an unnecessary assumption. As biology advances, we learn every day the function of characters which had before appeared to us to be useless, and the whole tendency of investigation is to prove that all characters whatsoever are either of direct use to their present possessors or have been inherited from ancestors, to whom, at the time when they were acquired, they were equally advantageous. It would be difficult to cite a stronger instance of a "morphological character" than the alternation of generations which so clearly characterizes the higher cryptogams. Yet it has been lately shown by Prof. Bower that this may well have been an adaptive character at its first origin, the sporophyte being adapted for taking possession of the dry land, while the oophyte, owing to the mode of fertilization, was compelled to retain a lowly and semi-aquatic habit.

We have given a very incomplete and imperfect sketch of the life-work of one of the most illustrious of that illustrious band of botanists to whom the chief advances of our science are due. Much of his work has of necessity been left quite unnoticed. But on even a cursory glance through the writings of Nägeli the conviction is forced upon us that he was a man not only of exceptionally wide scientific and philosophical training and of great literary power, but also one of real genius, and as far removed as possible from that narrow specialism which is the besetting sin of so much modern scientific effort. The judgment of Nägeli's colleague, Prof. Cramer, that he was "a truly great man," cannot be dismissed as the exaggerated language of personal affection, but expresses a truth. Though some of his theories may be abandoned, a vast sum of permanent achievement will always remain, and the influence of Nägeli on the future of our science will be powerful and lasting.

D. H. SCOTT.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—Full term commences on Saturday, October 17. The following lectures in science generally have been advertised :—

The Savilian Professor of Geometry (J. J. Sylvester) will lecture on surfaces of the second order, illustrated by the models with which that department has been supplied at the request of the Professor.

The Professor of Astronomy (Rev. C. Pritchard) proposes to lecture on the methods of determining astronomical constants, and offers practical instruction with the transit circle and solar spectroscope.

Rev. Bartholomew Price (Sedleian Professor of Natural Philosophy) lectures on hydromechanics.

The Professor of Experimental Philosophy (R. B. Clifton) will lecture on electricity; and instruction in practical physics is offered by Mr. Walker and Mr. Hatton at the Clarendon Laboratory. Lectures on mechanics and experimental physics are offered by Rev. F. J. Smith, at the Millard Laboratory.

The Waynflete Professor of Physiology (J. S. Burdon-Sanderson) will lecture on the subjects required for the final examination in the School of Physiology, and Mr. Dixey will lecture on histology. Practical instruction on this latter subject will be given by Mr. Kent.

In the subject of Chemistry, the Waynflete Professor (W. Odling) will lecture on animal products, while the Aldrichian Demonstrator (W. W. Fisher) will give a series of lectures on the non-metallic elements. Mr. J. Watts lectures on organic chemistry, and the instruction in practical work is under the supervision of Mr. Watts, Mr. Veley, and Mr. J. E. Marsh.

The Deputy Linacre Professor of Human and Comparative Anatomy (E. Ray Lankester) offers a course of lectures on comparative anatomy and embryology. This course is intended for seniors. There will also be a junior course for beginners and candidates for the preliminary examination in animal morphology conducted by the Deputy Linacre Professor and Dr. W. B. Benham. This last-named gentleman will also lecture on the Chætopoda.

The Professor of Geology (A. H. Green) offers two courses of lectures, one on physical, the other on stratigraphical geology.

The Reader in Anthropology (E. B. Tylor) will lecture on the origin and development of language and writing.

The Sherardian Professor of Botany (S. H. Vines) lectures, this term, on elementary botany.

The Hope Professor of Zoology (J. O. Westwood) lectures and gives informal information upon some of the orders of Arthropoda.

In the department of medicine, Sir H. W. Acland, Bart., gives informal instruction on modes of medical study. This instruction is given at the Museum, where arrangements will be made for one or more demonstrations in illustration of subjects bearing on public health. Dr. Collier and Mr. Morgan give demonstrations for the Professor on Medical and Surgical Pathology. The Lichfield Lecturer in Clinical Medicine (W. Tyrrell Brooks) will lecture on the physical signs of disease, and the Lecturer in Clinical Surgery (A. Winkfield) offers instruction on the treatment of fractures, &c.

The Lecturer in Human Anatomy (A. Thomson) offers a course of lectures on human osteology, and a series of demonstrations will be arranged to meet the requirements of those working in the department. The dissecting-room will be open daily for practical work and instruction.

The Rev. H. Boyd, Principal of Hertford College, has been nominated Vice-Chancellor for the ensuing year.

A mathematical fellowship has been awarded at Merton College to Mr. Arthur Lee Dixon, B.A., formerly scholar at Worcester College. Mr. Dixon was placed in the first class both at Moderations and in the final Mathematical Schools. He obtained the Junior Mathematical Scholarship in 1887 and the Senior Mathematical Scholarship in 1891. Also at Corpus Christi College a mathematical fellowship has been awarded to Mr. Arthur Ernest Jolliffe, scholar of Balliol College. Mr. Jolliffe was placed in the first class by the Mathematical Moderators in 1889, and in the first class by the Examiners in Scientiis mathematicis et physicis in 1891. He also obtained the Junior Mathematical Scholarship in 1889.

CAMBRIDGE.—The erection of the Newall telescope is nearly completed. Prof. Adams was able to use it for the first time last week, and took an observation of Neptune.

Prof. Ewing announces that the new Engineering Laboratory is ready for use, and will be occupied this term.

Mr. F. Blackman, of St. John's College, has been appointed Demonstrator of Botany.

By the return of Prof. Jebb, the University enjoys the distinction of being represented in Parliament by a Senior Classic (Dr. Jebb) and a Senior Wrangler (Sir G. G. Stokes).

Sixty-four candidates entered for the examination in sanitary science held last week. Of these forty-three have passed both parts of the examination, and receive the diploma in Public Health.

The Lecturer in Geography (Mr. Buchanan, F.R.S.) will this term lecture on physical and chemical geography, with especial reference to land surfaces and their development under climatic and other agencies.

The vote in the Senate on the question whether a syndicate shall be appointed to consider alternatives for Greek and Latin in the Previous Examination will be taken on Thursday, October 29, at 2 p.m.

University Extension.—It is announced that Mr. T. D. Galpin, of the firm of Cassell and Co., Limited, has offered to the Dorset County Council the sum of £1000 to be invested for the purpose of providing scholarships to send natives of Dorset to the Summer Meetings of Oxford and Cambridge. The scholarships will be awarded to the writers of the best essays, and it is proposed that the examination should be conducted by the University Extension Committee of the Oxford Delegates of Local Examinations. The scholarships are to be awarded without distinction of sex, or any political, sectarian, or social distinction whatever.

SCIENTIFIC SERIALS.

THE *American Journal of Science*, October 1891. Some of the possibilities of economic botany, by George Lincoln Goodale. This is the Presidential address delivered before the American Association for the Advancement of Science, at Washington in August last.—On the vitality of some annual plants, by T. Holm. The author enumerates several species of plants which show a tendency to vary from annual to biennial or perennial.—A method for the separation of antimony from arsenic by the simultaneous action of hydrochloric and hydriodic acids, by F. A. Gooch and E. W. Danner.—Notes on allotropic silver, by M. Carey Lea. The blue form of allotropic silver is mainly considered. The action of light on this form is remarkable, for its effect is first to increase the sensitiveness to reagents and then to completely destroy it. This reversing action is analogous to that which light exerts upon silver bromide. Mr. Lea has also examined the point as to whether in the reduction of silver, the allotropic or the normal form is produced, and he finds that when the silver passes from the condition of the normal salt or oxide to that of the metal, the reduced silver always appears in the ordinary form. But when the change is first to sub-oxide or to a corresponding sub-salt, the silver presents itself in one of its allotropic states.—Structural geology of Steep Rock Lake, Ontario, by Henry Lloyd Smyth.—On the so-called amber of Cedar Lake, North Saskatchewan, Canada, by B. J. Harrington. The resin or "retinite" examined by the author had a hardness of about 2·5, and a specific gravity 1·055 at 20° C. An analysis gave for its composition, carbon 80·03, hydrogen 10·47, and oxygen 9·50.—Geological horizons as determined by vertebrate fossils, by O. C. Marsh. The method of defining geological horizons by vertebrate fossils was first used by the author in 1877, and appears to afford the most reliable evidence of climatic and other geological changes. It is now extended and revised. A section accompanies the paper representing, in their geological order, the successive strata at present known with certainty from characteristic vertebrate fossils.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, October 3.—M. Duchartre in the chair.—On the variations of composition of Jerusalem artichokes from the point of view of mineral matters, by M. C. Lechartier. The author gives the results of some investigations made at the Rennes Agricultural Station, on the culture of artichokes in soils differently treated. He has also studied atmospheric influences as indicated by cultures on similar plots for three consecutive years.—Observations of Wolf's comet made with the great telescope of Toulouse Observatory, by M. E. Cosserat. Observations for position were made and are recorded, extending from August 13 to September 28.—On the value of electrostatic tension in a dielectric, by M. L. de la Rive.—On the simultaneous existence, in cultures of *Staphylocoque pyogène*, of a vaccine substance capable of being precipitated by alcohol, and of a substance soluble in alcohol, by MM. A. Rodet and J. Courmont.—On some parasite Copepods, by M. Eugène Canu.—Observations of the fall of a solar prominence into a spot, by M. E. L. Trouvelot. The observations relate to some remarkable luminous filaments occurring in a group of spots from August 6 to August 10.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

The Physical Geology and Geography of Ireland: E. Hull, 2nd edition (Stanford).—On Surrey Hills, a Son of the Marshes (Blackwood).—By Seashore, Wood, and Moorland: E. Step (Partridge).—An Introduction to Human Physiology: Dr. A. D. Waller (Longmans).—Guide to the Examinations in Physiography, and Answers to Questions: W. J. Harrison (Blackie).—Journal of the Chemical Society, October (Gurney and Jackson).—London and Middlesex Note-book, vol. i., No. 3 (E. Stock).—Botanischer Jahrbücher für Systematik' Pflanzengesschichte und Pflanzengeographie, Vierzehnter Band, 3 Heft (Leipzig, Engelmann).—Quarterly Journal of the Royal Meteorological Society, July (Stanford).—Meteorological Record, vol. x. No. 40 (Stanford).—Himmel und Erde, October (Berlin).

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