



A WEEKLY ILLUSTRATED JOURNAL OF SCIENCE.

*"To the solid ground  
Of Nature trusts the mind which builds for aye."*—WORDSWORTH.

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TWENTY YEARS.

A REMINDER that to-day is the twentieth anniversary of the first issue of *NATURE*, will not, perhaps, be without interest to our readers, and certainly affords food for reflection to those who in various capacities have been more or less closely connected with this journal from the first.

"When another half-century has passed," said Prof. Huxley in our first number, "curious readers of the back numbers of *NATURE* will probably look on *our* best 'not without a smile.'"

It will probably be so, but though twenty years is hardly a sufficient interval to make our smiles at our earlier efforts supercilious, it is enough to test whether progress has been made, and whether the forward path is pursued with growing or with waning force.

As regards this journal itself, we may claim that it has not disappointed the hopes of its founders, nor failed in the task it undertook; and we make this claim all the more emphatically because we feel that what has been accomplished has not been due to our own efforts so much as to the unflinching help we have always received from the leaders in all branches of natural science. This help has not been limited to their contributions to our columns, but has consisted also of advice and suggestions which have been freely asked and as freely given. Not the least part of our duty, and even privilege, to-day is to state openly how small our own part has been, and to render grateful thanks to those to whom it is chiefly due that *NATURE* has a recognized place in the machinery of science, and has secured an audience in all parts of the civilized world.

We do not wish, however, to narrow our retrospect of  
VOL. XLI.—No. 1045.

the last twenty years by confining our attention to the measure of success which these pages have won. It has been attained, as we have shown, by the aid of nearly all the best-known scientific writers and workers, not in Britain only but in many countries old and new; and we cannot believe that they would thus have banded themselves together if evidence had not been given of an honest desire for the good of science and for the "promotion of natural knowledge," or if the attainment of these objects had not been regarded by us as of more importance than a journalistic success. Thus, on its twentieth birthday, we would think not so much of the growth of *NATURE* as of the advance which in the last twenty years it has chronicled.

A formal history of science for that period would be a formidable task, but it is already possible to discern what will probably appear to posterity to be the most salient characteristics of the last two decades.

In the physical sciences, the enormous development of the atomic theory, and the establishment of a connection between the theories of electricity and light, are perhaps the two main achievements of the years we are considering. Methods of accomplishing the at first sight impossible task of measuring atomic magnitudes have been devised. Our own volumes contain some of the most interesting papers of Sir William Thomson on this subject, and the close agreement in the results attained by very different methods is sufficient proof that, if only approximations, they are approximations we may trust. The brilliant vortex atom theory of Sir William Thomson has not as yet achieved the position of a proved hypothesis, but has stimulated mathematical inquiry. A number of very powerful researches have added to our knowledge of a most difficult branch of mathematics, which may yet furnish the basis of a theory which shall deduce the nature of matter and the phenomena of radiation from a single group of assumptions.

The theory of gases has been extended in both direc-

tions. The able attempt of Van der Waals to bring both vapour and liquid within the grasp of a single theory is complementary to the extension by Crookes, Hittorf, and Osborne Reynolds of our knowledge of phenomena which are best studied in gases of great tenuity.

The gradual expansion of thermodynamics, and in general of the domain of dynamics from molar to molecular phenomena, has been carried on by Willard Gibbs, J. J. Thomson, and others, until, in many cases, theory seems to have outrun not only our present experimental powers, but almost any conceivable extension which they may hereafter undergo.

The pregnant suggestion of Maxwell that light is an electro-magnetic phenomenon has borne good fruit. Gradually the theory is taking form and shape, and the epoch-making experiments of Hertz, together with the recent work of Lodge, J. J. Thomson, and Glazebrook, furnish a complete proof of its fundamental hypotheses. The great development of the technical applications of electricity has stimulated the public interest in this science, and has necessitated a more detailed study of magnetism and of the laws of periodic currents. The telephone and the microphone have eclipsed the wonders of the telegraph, and furnish new means of wresting fresh secrets from Nature.

Science has become more than ever cosmopolitan, owing chiefly to the imperative necessity for an early agreement as to the values of various units for a common nomenclature, and for simultaneous observations in widely separated localities. International Conferences are the order of the day, and the new units which they have defined are based upon experiments by many first-rate observers in many lands, amongst whom the name of Lord Rayleigh stands second to none.

On the side of chemistry the periodic law of Mendeleeff has become established as a generalization of the first importance, and the extraordinary feat of foretelling the physical properties of an as yet undiscovered element has attracted to it the attention of the whole scientific world.

The once permanent gases are permanent no more. Dulong and Petit's law has found a complement in the methods of Raoult. The old doctrine of valency is giving way to more elastic hypotheses. The extraordinary progress of organic chemistry, which originated in the work and influence of Liebig and the Giessen school, has continued at an accelerated rate. The practical value of even the most recondite investigations of pure science has again been exemplified by the enormous development of the coal-tar industry, and by the numerous syntheses of organic products which have added to the material resources of the community.

The increase of our knowledge of the sun by means of localized spectroscopic observation, the application of photography to astronomy, and more recently still the extension and generalization of the nebular hypothesis are perhaps the most remarkable developments of those

branches of science which relate to astronomy. Stars which no human eye will ever see are now known to us as surely as those which are clearly visible. The efforts to reduce nebulae, comets, and stars under one common law, as various cases of the collision or aggregation of meteoritic swarms, and the striking investigations of Prof. Darwin on the effects of tidal action, and on the application of the laws of gases to a meteoritic plenum, give promise of a fuller knowledge of the birth and death of worlds.

In the biological sciences, the progress during the last twenty years has consisted chiefly in the firm establishment of the Darwinian doctrine, and the application of it and its subordinate conceptions in a variety of fields of investigation. The progress of experimental physiology has been marked by increasing exactitude in the application of physical methods to the study of the properties of living bodies, but it has not as yet benefited, as have other branches of biology, from the fecundating influence of Darwin's writings: hence there is no very prominent physiological discovery to be recorded. The generation of scientific men which is now coming to middle age has been brought up in familiarity with Mr. Darwin's teaching, and is not affected by anything like hostility or a *priori* antagonism to such views. The result is seen in the vast number of embryological researches (stimulated by the theory that the development of the individual is an epitome of the development of the race) which these twenty years have produced, and in the daily increasing attention to that study of the organism as a living thing definitely related to its conditions which Darwin himself set on foot. The marine laboratories of Naples, Newport, Beaufort, and Plymouth, have come into existence (as in earlier years their forerunners on the coast of France), and served to organize and facilitate the study of living plants and animals. The *Challenger* and other deep-sea exploring expeditions have sailed forth and returned with their booty, which has been described with a detail and precision unknown in former times. The precise methods of microscopic study by means of section-cutting—due originally to Stricker, of Vienna—have within these twenty years made the study of cell-structure and cell-activity as essential a part of morphology as it had already become of physiology. These, and the frank adoption of the theory of descent, have swept away old ideas of classification and affinities, and have relegated the Ascidian "ipolyps" of old days to the group of Vertebrata, and the Sponges to the Cœlenterates. The nucleus of the protoplasmic cell—which twenty years ago had fallen from the high position of importance accorded to it by Schwann—has, through the researches of Bütschli, Flemming, and Van Beneden, been reinstated, and is now shown to be the seat of all-important activities in connection with cell-division and the fertilization of the egg. The discovery of

the phenomena of karyokinesis and their relation to fertilization will be reckoned hereafter as one of the most, if not the most, important of the biological discoveries of the past twenty years.

Apart from Darwinism, the most remarkable development of biological studies during these "twice ten tedious years" is undoubtedly the sudden rise and gigantic progress of our knowledge of the Bacteria. Though the foundations were laid fifty years ago by Schwann and Henle, and great advances were made by Pasteur and by Lister just before our period, yet it is within this span that the microscope and precise methods of culture have been applied to the study of the "vibrios," or "microbes," and the so-called "bacteriology" established. We now know, through the labours of Toussaint, Chauveau, Pasteur, and Koch, of a number of diseases which are definitely caused by Bacteria. We also have learnt from Pasteur how to control the attack of some of these dangerous parasites. Within these twenty years the antiseptic surgery founded by Sir Joseph Lister has received its full measure of trial and confirmation, whilst his opportunities and those of his fellow-countrymen for making further discovery of a like kind have been ignorantly destroyed by an Act of Parliament.

To particularize some of the more striking zoological discoveries which come within our twenty years, we may cite—the Dipnoous fish-like creature *Ceratodus* of the Queensland rivers, discovered by Krefft; the jumping wheel-animalcule *Pedalion*, of Hudson; the development and the anatomy of the archaic Arthropod *Peripatus* worked out by Moseley, Balfour, and Sedgwick; the Hydrocorallinae of Moseley, an entirely new group of compound animals; the fresh-water jelly-fish *Limnocoedium* of the Regent's Park lily-tank; the Silurian scorpion of Gotland and Lanarkshire; the protozoon *Chlamydomyxa* discovered by Archer in the Irish bogs; the Odontornithes and the Dinocerata of the American palæontologists; the intracellular digestion obtaining in animals higher than Protozoa, and the significance of the "diapedesis" of blood-corpuscles in inflammation, and the general theory of phagocytes due to Mécznikow; the establishment of the principle of degeneration as of equal generality with that of progressive development, by Anton Dohrn; the demonstration by Weismann and others that we have no right to mix our Darwinism with Lamarckism, since no one has been able to bring forward a single case of the transmission of acquired characters. Perhaps the attempt to purify the Darwinian doctrine from Lamarckian assumption will hereafter be regarded—whether it be successful or not—as the most characteristic feature of biological movement at the end of our double decade. Its earlier portion was distinguished by the publication of some of Darwin's later works. Its greatest event was his death.

In botany, twenty years ago, the teaching in our Universities was practically sterile. In one of our earliest numbers, Prof. James Stewart defended with some vigour the propriety of intrusting botany to a lecturer at Cambridge who was also charged with the duty of lecturing on electricity and magnetism. It is startling to compare a past, in which botany was regarded as a subject which might be tacked on anywhere, with its present condition, in which there is scarcely a seat of learning in the three kingdoms which is not turning out serious work. The younger English school would be ungrateful if it did not acknowledge its debt to the eminent German teachers from whom it has derived so much in the tradition and method of investigation. Sachs and De Bary have left an indelible mark on our younger Professors. But it would be a mistake to suppose that English modern botany has simply derived from Germany. It has developed a character of its own, in which the indirect influence of Darwin's later work can be not indistinctly traced. There has been a gradual revolt in England, the ultimate consequences of which have still to be developed, against the too physical conception of the phenomena of plant life which has been prevalent on the Continent. Darwin, by his researches on insectivorous plants and plant movements from a purely biological point of view, prepared the way for this; Gardiner followed with a masterly demonstration of the physical continuity of protoplasm in plant tissues. This has thrown a new light on the phenomena studied by Darwin, and we need not, therefore, be surprised that his son, F. Darwin, has started what is virtually a new conception of the process of growth, by showing that its controlling element is to be sought in the living protoplasm of the cell, rather than in the investing cell-wall. On the whole, English botanists have shown a marked disposition to see in the study of protoplasm the real key to the interpretation of the phenomena of plant life. The complete analogy between the processes of secretion in animals and vegetables, established by Gardiner, and the essential part played by ferments in vegetable nutrition, illustrated by Green, are examples of the results of this line of inquiry. To Germany we owe a flood of information as to the function of the cell-nucleus, which it is singular has met with general acceptance but little detailed corroboration in this country.

In morphology a review would be ineffective which did not go somewhat deeply into detail. The splendid hypothesis of Schwendener, of the composite nature of lichens as a commensal union of Algae and Fungi, has gradually won its way into acceptance. In England there is little of the first rank which calls for note except the researches of Bower on the production of sexual organs on the leafy plant in ferns without the intervention of an intermediate generation.

In vegetable physiology there seems a pause; the

purely physical line of inquiry, as already suggested, seems to have yielded its utmost. The more biological line of inquiry has only yet begun to yield a foretaste of the results which will undoubtedly ultimately flow from it.

Something must be added as to systematic and geographical botany. The "Genera Plantarum" of Bentham and Hooker, the work of a quarter of a century at Kew, affords a complete review of the higher vegetation of the world, and has been accepted generally as a standard authority. To Bentham also we owe the completion of the "Flora Australiensis," the first complete account of the flora of any great continent.

In geographical botany, perhaps the most interesting results have been the gradual elaboration of a theory as to the distribution of plants in Africa, and the botanical exploration of China, of the vegetable productions of which, twenty years ago, almost nothing was known.

In the classification of the lower plants, perhaps the most interesting result has been the happy observations of Lankester upon a coloured Bacterium, which enabled him to show that many forms previously believed to be distinct might be phases of the same life-history.

In geology probably the greatest advance has been in the application of the microscope to the investigation of rock structure, which has given rise to a really rational petrology. All except the coarser-grained rocks were only capable of being described in vague terms; with modern methods their crystalline constituents are determinable, however minute, and the conditions under which they were formed can be inferred.

It is, impossible, even in a brief review of this kind, to think only of what has been won, and to ignore the loss of leaders who were once foremost in the fray. In England three names which will never be forgotten have been removed from the muster-roll. Darwin, Joule, and Maxwell can hardly be at once replaced by successors of equal eminence. As the need arises, however, men will no doubt be found adequate to the emergency, and it is at least satisfactory to know that they will appeal to a public more capable than heretofore of appreciating their efforts.

The support afforded by the Governments of Western Europe to scientific investigation has been markedly increased within the period which we survey. France has largely extended her subsidies to scientific research, whilst Germany has made use of a large part of her increased Imperial revenue to improve the arrangements for similar objects existing in her Universities. The British Government has shown a decided inclination in the same direction: the grant to the Royal Society for the promotion of scientific research has been increased from £1000 to £4000 a year; whilst subsidies have been voted to the Marine Laboratory at Plymouth, to the Committee on Solar Physics, to the Meteorological Council, and quite recently

to the University Colleges throughout the country, of which last it is to be hoped that a fair proportion will be devoted to the promotion of research rather than to the reduction of class fees.

Twenty years ago England was in the birth-throes of a national system of primary instruction. This year has seen the State recognition of the necessity of a secondary and essentially a scientific system of education, and the Technical Instruction Act marks an era in the scientific annals of the nation.

The extension of scientific teaching has gone on rapidly within and without our Universities. Twenty years ago the Clarendon Laboratory at Oxford was approaching completion, and was the only laboratory in the country which was specially designed for physical work. Now, not only has Cambridge also its Cavendish Laboratory, but both Universities have rebuilt their chemical laboratories, both have erected buildings devoted to the study of biology, and the instruction of students in both zoology and botany has taken a characteristic practical form which we owe to the system of concentrating attention on a series of selected "types" introduced by Rolleston and by Huxley. Oxford has been furnished with an astronomical observatory by the liberality of Warren De la Rue, and Cambridge has accepted the noble gift of the Newall telescope. Nor have such proofs of the vitality of science been confined to the Universities.

Twenty years ago the Owens College was a unique institution: now, united with two thriving Colleges in Leeds and Liverpool, it forms the Victoria University; while science is studied in appropriate buildings in Birmingham, Newcastle, Nottingham, and half a dozen towns beside.

A race is thus springing up which has sufficient knowledge of science to enforce due recognition of its importance, and public opinion can now, far more than in the past, be relied on to support its demands. Fortunately, too, these can be authoritatively expressed. The Royal Society wields, if it chooses to exercise it, an enormous power for good. Admitted on all hands to be the supreme scientific authority in this country, its decisions are accepted with a deference which can spring only from respect for the knowledge and scrupulous fairness by which they are dictated. If sometimes it moves slowly, *pur se muove*, and it is delightful to turn from the babble of the politicians to the study of an institution which does its work well, and perhaps too noiselessly. But even the House of Commons, hitherto ignorant and therefore apathetic in matters scientific, is awakening to the fact that there are forces to be reckoned with and impulses to be stimulated and controlled which are of more enduring import to the national welfare than mere party politics. And the people, too, are beginning to see that it is to the economic working of these forces, and to the right direction of these impulses, that their representatives are bound to give attention. True it is that



another generation may possibly pass away before either the House of Commons or even Ministers are sufficiently instructed in science to recognize fully their responsibility in this direction.

Whatever, then, the future may bring, the last twenty years have been characterized by progress both steady and rapid. The tide flows on with no sign of check, and we accept the success of NATURE in no spirit of self-gratulation, but as a straw by which the speed of the current may be gauged.

#### MODERN VIEWS OF ELECTRICITY.

*Modern Views of Electricity.* By Oliver J. Lodge, D.Sc., LL.D., F.R.S. (London: Macmillan and Co., 1889.)

IN this interesting book Prof. Lodge gives a very lively and graphic account of many of the most recent speculations about the nature of electrical phenomena. A work with this object was urgently needed, as the method of regarding these phenomena given in popular treatises on electricity is totally different from that used by those engaged in developing the subject.

The attention called by Faraday and Maxwell to the effects produced by and in the medium separating electrified bodies has had the effect of diverting attention from the condition of the charged bodies in the electric field to that of the medium separating them, and it is perhaps open to question whether this of late years has not been too much the case. To explain the effects observed in the electric field we should require to know the condition not only of the ether, but also of the conductors and insulators present in it; just as a complete theory of light would include the state of the luminous bodies as well as of the ether transmitting the radiations excited by them. Since matter is more amenable to experiment than the ether, it seems most probable that we shall first gain an insight into the nature of electricity from a study of those cases where matter seems to play the chief part—such as in the electric discharge through gases, and the phenomena of electrolysis—rather than from speculations, however interesting, as to what takes place in the ether when it is transmitting electrical vibrations. Prof. Lodge, however, in the work under consideration, devotes most of his space to the consideration of the ether. In his preface he says, "Few things in physical science appear to me more certain than that what has so long been called electricity is a form, or rather a mode, of manifestation of the ether;" and he proceeds to give precision to this somewhat vague statement by developing a theory that electricity is a fluid, and a constituent of a very complex ether. In the first few chapters he supposes that all insulators, including the ether, have a cellular structure the cells being filled with a fluid which is electricity, and which is not able to get from one cell to another unless the walls of the cells are broken down; in conductors, however, there are channels between the cells, so that the electricity is able to flow more or less freely through them. A flow of this fluid is an electric current. But if this is the case, anything which sets the ether in motion will produce an electric current. Now, Fizeau's experiments show that moving bodies carry the ether with them to an extent depending on their index

of refraction; so that a disk made of glass or other refracting substance, if set in rapid rotation about an axis through its centre, and at right angles to its plane, ought to act as if currents were circulating in the disk, and produce a magnetic field around it. In order to avoid the allied difficulty that nothing has ever been observed which indicates that a magnet or a current flowing through a coil possesses gyroscopic properties, Prof. Lodge assumes, in subsequent chapters, that the fluid in the cells of the ether is a mixture of two fluids, and that these two fluids are positive and negative electricity: and that, in order to exhibit any electrical effect, the compound fluid has first to be decomposed into positive and negative electricity by the application of an electromotive force. A current of electricity, on this view, consists of the flow of equal quantities of positive and negative electricity in opposite directions. Thus this, the most "modern view of electricity," is in its most important features almost identical with the old two-fluid theory published by Symmer in 1759. We confess we do not think the theory in its present form advances the science of electricity much: it does not suggest new phenomena, nor does it lend itself readily to explain the action of matter in modifying electrical phenomena; it demands, too, a very artificial ether. It would seem that the first steps required to make a theory of this kind a real advance on the old two-fluid theory would be the discovery of a structure for the ether, which would possess the same kind of properties as the mixture of the two electricities on that theory. A great deal, too, is left indefinite in the theory: thus, for example, we are not told whether for a given current these streams are moving slowly or with prodigious velocities. In fact, there is throughout the book rather a want of definite conclusions, and this is rather hidden by the vigorous style in which Prof. Lodge writes: he develops his ideas in such an enthusiastic and interesting way that on the first reading they seem to be a good deal more definite than they prove to be on calmer reflection.

But whatever may be thought of Prof. Lodge's theory of electricity, there can be, we think, no two opinions of the value of the numerous models illustrating the properties of electrical systems which he has invented. These must prove of the greatest assistance in enabling the student to gain a clear and vivid idea of electrical processes, and ought to be largely employed by all teachers of electricity.

In a work dealing so briefly with such a multitude of different and difficult subjects it is natural that there should be many statements to which exception might be taken. Prof. Lodge disarms criticism by his frank admission of this; sometimes, also, by an amusing vagueness of statement: thus, on p. 206, in speaking of the condition of the ether inside a strongly-magnetizable substance, he says: "Perhaps it is that the atoms themselves revolve with the electricity; perhaps it is something quite different." There are, however, some statements of a less theoretical kind which seem to us likely to mislead the student. Thus it is stated that the amount of the Peltier effect shows that the difference of potential between zinc and copper is only a few micro-volts. The Peltier effect, however, without further assumption, cannot tell us anything about the absolute magnitude of the difference of

potential between the metals; it can only give us the value of the temperature coefficient, which is equal to the Peltier effect divided by the absolute temperature. Then, again, the pyro-electricity of tourmaline is explained by the unilateral conductivity of a tourmaline crystal whose temperature is changing, discovered by the author and Prof. Silvanus Thompson. If this unilateral conductivity is regarded as proving the existence of an electromotive force in a crystal which is increasing or decreasing in temperature, the explanation is valid, but in the text nothing is said about an electromotive force, and the student might be led to infer that a mere difference in resistance could explain pyro-electricity. The way in which a current flows past an insulating obstacle, the lines of flow closing in on the obstacle, and leaving nothing corresponding to "dead water" behind it, is given as a proof that the electric current has no mechanical momentum; but unless the corners of the obstacle were infinitely sharp, a slowly-moving fluid might flow in the same way as electricity, even though it possessed inertia, so that the proof is not conclusive. It is also stated that the effects on light produced by a magnetized body, discovered by Dr. Kerr, of Glasgow, have been deduced by Prof. Fitzgerald from Maxwell's theory of light. As a matter of fact, however, the results deduced from this theory by Fitzgerald do not coincide with those observed by Dr. Kerr and Prof. Kundt. The production in an unequally-heated conductor of an electromotive force is explained by supposing the atoms in such a body to be moving faster in one direction than the opposite, and therefore, since they are supposed to drag the ether with them, producing a flow of ether in the direction in which they are moving fastest; but, on the dualistic theory of electricity adopted in this book, this ether stream would consist of equal quantities of positive and negative electricity moving in the same direction, and this would not produce any electrical effect.

At the end of the book are three popular lectures delivered by Prof. Lodge, the first on the relation between electricity and light, the second on the ether and its functions, and the third his admirable one at the Royal Institution, on the discharge of a Leyden jar, which is a model of what such a lecture ought to be.

Taken as a whole, we think that the book is one which ought to be read by all advanced students of electricity; they will get from it many of the views which are guiding those who are endeavouring to advance that science, and it is so stimulating that no one can read it without being inspired with a desire to work at the subject to which it is devoted.

#### THE CALCULUS OF PROBABILITIES.

*Calcul des Probabilités.* Par J. Bertrand. (Paris: Gauthier-Villars, 1889.)

"EVERYBODY makes errors in Probabilities at times, and big ones," writes De Morgan to Sir William Hamilton. M. Bertrand appears to form an exception to this dictum, or at least to its severer clause. He avoids those slips in the philosophical part of the subject into which the greatest of his mathematical predecessors have fallen. Thus he points out that, in investigating the

"causes" of an observed event, or the ways in which it might have happened, by means of the calculus of probabilities, it is usual to make certain unwarranted assumptions concerning the so-called *a priori* probability of those causes. Suppose that a number of black and white balls have been drawn at random from an urn, and from this datum let us seek to determine the proportion of black and white balls in the urn. It is usual to assume, without sufficient grounds, that *a priori* one proportion of balls, one constitution of the urn, is as likely as another. Or suppose a coin has been tossed up a number of times, and from the observed proportion of heads and tails let it be required to determine whether and in what degree the coin is loaded. Some assumption must be made as to the probability which, prior to, or abstracting from, our observations, attaches to different degrees of loading. The assumptions which are usually made have a fallacious character of precision.

Again, M. Bertrand points out that the analogy of urns and dice has been employed somewhat recklessly by Laplace and Poisson. It is true that the ratio of male to female births has a constancy such as the statistics of games of chance present. But, before we compare boys and girls to black and white balls taken out at random from an urn, we must attend not only to the average proportion of male to female births, but also to the deviations from that average which from time to time or from place to place may be observed. The analogy of urns and balls is more decidedly inappropriate when it is applied to determine the probable correctness of judicial decisions. The independence of the judges or jurymen which the theory supposes does not exist.

"Quand un juge se trompe il y a pour cela des raisons: il n'a pas réellement mis la main dans une urne où le hasard l'a mal servi. Il a ajouté foi à une faux témoignage, le concours fortuit de plusieurs circonstances a éveillé à tort sa défiance, un avocat trop habile l'a ému, de hautes influences peut-être l'ont ébranlé. Ses collègues ont entendu les mêmes témoins, on les a instruits des mêmes circonstances, le même avocat a plaidé devant eux, on a tenté sur eux la même pression."

With equal force does M. Bertrand expose the futility of the received reasoning by which it is pretended to determine the probability that the sun will rise to-morrow from the fact that it has risen so many days in the past.

These reflections are just and important; but their value is somewhat diminished by the fact that they have been, for the most part, made by previous writers with whom our author seems unacquainted. Thus Prof. Lexis has more carefully considered the extent of the error committed by Laplace and Poisson in applying to male and female births and other statistics rules derived from games of chance. The fundamental principles of Probabilities have been more fully explored by Dr. Venn. M. Bertrand, like Laplace, starts by defining the probability of an event as the ratio of the number of favourable cases to the number of possible cases. He does not explain what constitutes a "favourable case"—that, when a die is thrown, the probability of obtaining the 3 or 4 is one-sixth, because as a matter of fact each side in the long run turns up once out of six times. Accordingly, when he argues that in a great number of trials each event is most likely to occur with a frequency correspond-

ing to its probability, he lays himself open to the charge of circularity which Dr. Venn has brought against Bernoulli's theorem. Without pronouncing on this delicate question, we may safely say, with respect to the first principles of the subject, that no point which has been left obscure by Dr. Venn has been cleared up by M. Bertrand.

It is with respect to the purely mathematical portion of the calculus, or that part of its metaphysics which is inextricably mixed with mathematics, that we expected and have found most assistance from M. Bertrand. Hitherto the study of Probabilities has been barred by the dilemma which M. Bertrand thus states:—

"On ne peut bien connaître le calcul des probabilités sans avoir lu le livre de Laplace; on ne peut lire le livre de Laplace sans s'y préparer par les études mathématiques les plus profondes."

Much of Laplace's analysis which must have affected many eager students like stickjaw has been simplified by M. Bertrand. He is in general more readable than Poisson. Several of the theorems which he gives seem to be new. His methods of determining from a given set of observations the characteristic, or *modulus*, appertaining to the source of error are specially interesting.

M. Bertrand's mathematical power enables him to carry the torch of common-sense to those perplexed parts of the subject where less qualified critics, awed by the imposing mass of symbols, have hesitated to differ from Laplace or Poisson. Of this kind is the simultaneous determination of several quantities from a great number of equations. When Laplace computes that the odds are a million to one against the occurrence of an error of assigned magnitude in the determination of Jupiter's mass, M. Bertrand shows reasons for suspecting the accuracy of such computations. In fact, he carries out Poincaré's witty direction:

"Après avoir calculé la probabilité d'une erreur il faudrait calculer la probabilité d'une erreur dans le calcul."

The true import and proper application of the theory of errors of observation are thus well expressed:—

"On peut accepter sans crainte le résultat, mais il est téméraire d'évaluer en chiffres la confiance qu'il doit inspirer."

M. Bertrand teaches with authority—and not like those who have not followed the higher mathematical reasonings of the calculus—in what spirit its conclusions should be accepted.

Still, even with regard to those parts of the subject where a first-rate mathematician has so great an advantage, we venture to think that the work would have been much more valuable if the writer had taken the trouble to acquaint himself more fully with what his predecessors had done. For example, in discussing the reasons for taking the arithmetic mean of a set of observations (presumed to be equally good) relating to a single quantity, M. Bertrand does not dwell on the argument that the probability-curve—with which the arithmetic mean is specially correlated—is apt to represent the grouping of errors for this reason, that an error may be regarded as a function of a great number of elements each obeying some definite law of facility, and that the values of such a function conform to the probability-curve. It is true that Laplace, from

whom this argument may be derived, has not himself used it very directly. But in a writer on the method of least squares we may expect some converseance with more recent works, in particular with Mr. Glaisher's classical paper in the *Memoirs of the Astronomical Society* (London). Moreover, Laplace does employ the mathematical theorem which we have indicated, not indeed to prove that the law of facility for errors of observation in general is the probability-curve, but that, whatever that law of facility be, the most advantageous combination is a certain linear function. A treatise in which this celebrated argument is not discussed cannot be regarded as exhaustive. But it is remarkable that with respect to the combination of observations, M. Bertrand seems to defer more to Gauss than to his own eminent countryman.

M. Bertrand has indeed slipped in a doctrine for which the authority of Laplace may be quoted, that in choosing the best combination of a set of observations "there is an essential difference between the most probable value of a quantity and the value which it is best to adopt" (Bertrand, Art. 138); the latter being the mean (first power) of the observations (Art. 155)—which M. Bertrand rather awkwardly terms "la valeur probable." M. Bertrand does not seem to realize the gravity of the assumption which is contained in the latter clause. Later on he employs Gauss's criterion of erroneousity—namely, the mean square of error. But the ground, nature, and relation of these two principles are not very clearly explained by the writer. With respect to the philosophical foundation of the method of least squares he has not superseded the necessity of studying Laplace.

With these reservations, M. Bertrand's work may be regarded as one of the most complete treatises on the subject. Nowhere else are the two elements so peculiarly combined in the science of Probabilities—common-sense and mathematical reasoning—to be found existing together in such abundance.

F. Y. E.

#### ARGENTINE ORNITHOLOGY.

*Argentine Ornithology.* By P. L. Slater, Ph.D., F.R.S., and W. H. Hudson, C.M.Z.S. Vol. II. (London: W. H. Porter, 1889.)

THE completion of this important work is an event of considerable importance to every lover of neotropical zoology, and the authors have both performed their parts well, while the ten plates by Mr. Keulemans are beautifully drawn and admirably coloured. Among the increasing number of Englishmen who settle in the Argentine Republic, there are sure to be many who will pursue natural history studies, and to all such a well-executed book like the present will be invaluable. The joint authors of the work are happy in their association, for while Dr. Slater brings to the work a vast experience, and a sound scientific knowledge of his subject, it is certain that never was there a better describer of the habits of birds than Mr. Hudson. Although of English parentage, he is a native-born Argentine, and he has grown up among the birds whose life and history he so well knows how to portray. In turning over the pages of this volume, we have found many interesting extracts which we should have liked to present to our readers,



and we feel that we should not be doing justice to Mr. Hudson if we did not quote for their benefit one specimen of this naturalist's writing. He is describing the habits of the Carancho (*Polyborus tharus*):—

"When several of these birds combine they are very bold. A friend told me that while voyaging on the Paraná River a black-necked Swan flew past him hotly pursued by three Caranchos; and I also witnessed an attack by four birds on a widely different species. I was standing on the bank of a stream on the Pampas watching a great concourse of birds of several kinds on the opposite shore, where the carcass of a horse, from which the hide had been stripped, lay at the edge of the water. One or two hundred Hooded Gulls and about a dozen Chimangos were gathered about the carcass, and close to them a very large flock of Glossy Ibises were wading about in the water, while amongst these, standing motionless in the water, was one solitary white Egret. Presently four Caranchos appeared, two adults and two young birds in brown plumage, and alighted on the ground near the carcass. The young birds advanced at once and began tearing at the flesh; while the two old birds stayed where they had alighted, as if disinclined to feed on half-putrid meat. Presently one of them sprang into the air and made a dash at the birds in the water, and instantly all the birds in the place rose into the air screaming loudly, the two young brown Caranchos only remaining on the ground. For a few moments I was in ignorance of the meaning of all this turmoil, when, suddenly, out of the confused black and white cloud of birds the Egret appeared, mounting vertically upwards with vigorous measured strokes. A moment later, and first one, then the other, Carancho also emerged from the cloud, evidently pursuing the Egret, and only then the two brown birds sprang into the air and joined in the chase. For some minutes I watched the four birds toiling upwards with a wild zigzag flight, while the Egret, still rising vertically, seemed to leave them hopelessly far behind. But before long they reached and passed it, and each bird as he did so would turn and rush downwards, striking at the Egret with his claws, and while one descended the others were rising, bird following bird with the greatest regularity. In this way they continued toiling upwards until the egret appeared a mere white speck in the sky, about which the four hateful black spots were still revolving. I had watched them from the first with the greatest excitement, and now began to fear that they would pass from sight and leave me in ignorance of the result; but at length they began to descend, and then it looked as if the Egret had lost all hope, for it was dropping very rapidly, while the four birds were all close to it striking at it every three or four seconds. The descent for the last half of the distance was exceedingly rapid, and the birds would have come down almost at the very spot they started from, which was about forty yards from where I stood, but the Egret was driven aside, and sloping rapidly down struck the earth at a distance of two hundred and fifty yards from the starting point. Scarcely had it touched the ground before the hungry quartette were tearing it with their beaks. They were all equally hungry no doubt, and perhaps the old birds were even hungrier than their young; and I am quite sure that if the flesh of the dead horse had not been so far advanced towards putrefaction they would not have attempted the conquest of the Egret. I have so frequently seen a pure white bird singled out for attack in this way, that it has always been a great subject of wonder to me how the two common species of snow-white Herons in South America are able to maintain their existence; for their whiteness exceeds that of other white waterfowl, while, compared with Swans, Storks, and the Wood-ibis, they are small and feeble. I am sure that if these four Caranchos had attacked a Glossy Ibis they would have found it an easier

conquest; yet they singled out the egret, purely, I believe, on account of its shining white conspicuous plumage."

In his introduction Dr. Sclater gives a *résumé* of the number of genera and species inhabiting the Argentine Republic, and shows that the avifauna of that portion of South America belongs to the Patagonian sub-region. A little sketch-map would have been useful, to show the configuration of the country and the proportions of the mountain-ranges, as it is evident that a district which can boast of a Dipper, and be at the same time the home of two Cariamas, must possess elements of two very different avifaunæ. Some day, no doubt, an exact exploration, such as that now being undertaken in Mexico by Messrs. Salvin and Godman, will trace the limits of the avifaunæ of the Pampas and the mountain regions. If Mr. Hudson could only be induced to resume his work of exploration and visit the interior of the Argentine Republic, the results would be, we venture to say, of the first importance to science.

Dr. Sclater, we notice, draws his comparisons of the different orders of Argentine birds from the "Nomenclator Avium Neotropicalium" of 1873, which is rather ancient history. The statistics of American birds must have altered considerably since that date, if we may judge from the Tanagers alone, which numbered 302 species in 1873, and in 1886 had reached 377 in number, according to Dr. Sclater's own estimate. In dividing the Neotropical Region into the sub-regions he adopts the conclusions of Prof. Newton in the "Encyclopædia Britannica," but the names of one or two of them are changed. The boundaries seem to be extremely natural, according to our present state of knowledge, though we would scarcely consider the Central American sub-region (or the Trans-panamic sub-region, as Dr. Sclater renames it) to be bounded on the north by Tehuantepec! The author probably intended to give only a general outline, for the northern boundaries of the Central American sub-region are much more elaborately defined in fact.

R. BOWDLER SHARPE.

#### OUR BOOK SHELF.

*The Chemistry of the Coal-tar Colours.* From the German of Dr. R. Benedikt. Translated, with Additions, by Dr. E. Knecht. Second Edition. (London: George Bell and Sons, 1889.)

DR. BENEDIKT'S little book is a standard treatise in Germany, where the literature of the coal-tar colours is fast becoming a most important branch of the general literature of applied chemistry; and Dr. Knecht has done excellent service in making the work more generally known to English readers by means of his translation. It is remarkable that, although England may be said to have originated the coal-tar colour industry, she has contributed comparatively little to the general literature of the subject. Practically, all the systematized information we possess has come to us through the medium of French and German manuals. A number of our chemists could be named who have communicated original memoirs on the constitution of organic colouring-matters to the recognized organs of chemical research, but their work is very special in its character, and appeals rather to the pure chemist than to the technologist, and hence is seldom read by the latter. The want of a good, sound, and comprehensive treatise on the subject



of the coal-tar colour industry has, we think, not been without its influence on the development of this branch of applied organic chemistry in this country. Dr. Knecht's translation merits a place on the bookshelf of every person engaged in the manufacture and use of the so-called coal-tar colours.

*A Bibliography of Geodesy.* By J. Howard Gore, B.S., Ph.D. (Washington: Government Printing Office, 1889.)

THIS valuable work forms Appendix No. 16 to the 1887 Report of the United States Coast and Geodetic Survey, and is another example of the disinterested energy displayed by our Transatlantic cousins in scientific matters. With great perseverance, and at the cost of much time and trouble, Mr. Gore personally explored thirty-four of the principal libraries of America and Europe, and numerous minor libraries by proxy; and, in addition, he checked and completed many of his references by correspondence with the living authors of both continents. The extent of his labours is shown by the four hundred columns of references, and short remarks where the title alone is not sufficiently explanatory. An alphabetical arrangement is adopted, and this includes authors, abbreviations, and subjects.

It is gratifying to note that our own country, besides the assistance rendered by its libraries, lends its aid to such an important work in the shape of a manuscript supplement by Colonel Herschel to his pendulum bibliography, which was placed unreservedly at Mr. Gore's disposal, through the courtesy of the Royal Society. After the offers of publication made by various institutions, including the International Geodetic Association at Berlin, no further testimony to Mr. Gore's fitness for the work is needed, and the compiler is justly proud "to see the results of his labours issuing from an institution of his own country, which throughout the world is the recognized advance guard in geodetic science."

#### LETTERS TO THE EDITOR.

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

#### The Method of Quarter Squares.

I OMITTED any reference to Leslie in my review of Mr. Blater's table (NATURE, vol. xl. p. 573), as I have never supposed that he was an independent discoverer of the method, or an independent calculator of a table, of quarter squares. I have referred to his table in my Report on Mathematical Tables Brit. Assoc. Report, 1873, p. 23; and the passage quoted by Prof. Carey Foster (p. 593) is given in full in the preface to Mr. Blater's table. It seems to me that the words in question—"This application of a table of quarter squares, as it is derived from the simplest principles, might have readily occurred to a mathematician; yet I have nowhere seen it brought into practical use till, last summer, I met with, at Paris, a small book by Antoine Voisin, printed in 1817"—do not indicate an independent discovery; and this view is confirmed by the fact that, in the first edition of the "Philosophy of Arithmetic" (1817), Leslie makes no mention of quarter squares. It was only in the second edition (1820), after having seen Voisin's work in the previous year, that he added, at the end of the volume, an account of the method, and a table extending to 2000. The table was copied, I presume, from Voisin, as Leslie does not claim it as the result of his own calculation. In the British Association Report I have described it as "reprinted from Voisin," and have pointed out that it did not appear in the first edition. In the preface to Mr. Blater's letter it is described as "an extract from Voisin's table." Although we may, I think, infer, almost

with certainty, that the table is only a reprint,<sup>1</sup> it is to be regretted that Leslie did not say so explicitly.

J. W. L. GLAISHER.

Trinity College, Cambridge, October 26.

#### Darwinism.

MR. ROMANES states that it is "absurd" to call his essay on physiological selection an elaborate (I said "laborious") attack upon Mr. Darwin's theory of the origin of species. In that essay I find these words (p. 345), "the theory of natural selection has been misnamed: it is not strictly speaking a theory of the origin of species"; and on p. 403, "the theory of physiological selection [*i.e.* Dr. Romanes's theory] has this advantage over every other theory that has ever been propounded on the origin of species"; and again, "the problem of the origin of species which, as shown in the preceding paper [*viz.* the laborious essay], his [Mr. Darwin's] theory of natural selection serves only in small part to explain."

On the other hand, Mr. Darwin entitled his great work, "The Origin of Species by means of Natural Selection, or the preservation of favoured races in the struggle for life." He considered his theory of natural selection to be a theory of the origin of species. Mr. Romanes says it is not. I say that this is an attack on Mr. Darwin's theory, and about as simple and direct an attack as possible. Why Mr. Romanes wishes us to believe that he did not attack Mr. Darwin's theory it is difficult to conceive. That he should hope to persuade anyone that it is absurd to call his essay an attack on Mr. Darwin's theory when this is what it distinctly professes to be is curious. I trust you will not permit an empty discussion on this matter, but leave it to your readers to find out by reference to the Proc. Linn. Soc., vol. xix., where the absurdity exists.

E. RAY LANKESTER.

42 Half-moon Street, November 1.

#### Record of British Earthquakes.

WILL you allow me to ask your readers to help me in compiling notes of the earthquakes felt in this country during the present and following years?

Mr. Mallet's great Catalogue of all recorded earthquakes ends, as is well known, with the year 1842. Previously to this, Mr. David Milne had published a series of papers on the earthquakes of Great Britain in the *Edinburgh New Philosophical Journal* (vols. xxxi. to xxxvii. for the years 1841-44). These papers, which are of very great value, bring down our record to the end of August 1843. In recent years we have had the Catalogues of Prof. J. F. O'Reilly (Trans. Roy. Irish Acad., vol. xxvii. pp. 285-316 and 489-708) and the late Mr. W. Roper (published by T. Bell, Observer Office, Lancaster). The latter is a useful chronological list of shocks felt during the Christian era, down to February 10, 1889; but, except in a few cases, it is little more than a list. Prof. O'Reilly's important catalogues are arranged alphabetically according to the localities affected, and do not pretend to give detailed information with reference to the shocks themselves.

To make our seismic record more complete, I propose, therefore, to compile a descriptive list of British shocks noticed in newspapers and scientific journals from the time at which Mr. Milne's Catalogue closes down to the end of the year 1888; and I should be very grateful if your readers can in any way help me in this work.

What I wish particularly to ask for, however, is information relating to the shocks of the present and future years. For our knowledge of British earthquakes we must at present rely to a great extent on newspaper accounts; and these accounts, which for some points are fairly trustworthy, become difficult of access in after years. If any of your readers are willing to assist me in preserving these notices in a convenient and systematic form, may I ask if they would be good enough to send, to the address below, the names and dates of newspapers, and more especially local ones, in which any descriptions, however short, are given of British shocks? It is hardly necessary to say that any other notes, communicated by those who have felt the shocks or observed their effects, would be of great value, and would be most thankfully received.

The days are past for compiling earthquake catalogues for the

<sup>1</sup> After quoting the full title of Voisin's table, Leslie refers to his own table as "the specimen which I have given."

whole surface of the earth, and the value of an attempt at such a task would now be extremely doubtful. But for limited districts, like this country, the case is very different. It would indeed be difficult to over-estimate the value of a seismic record which can claim any approach to completeness for a definite earthquake area, however feeble the shocks which visit it may be.

I may add that I hope shortly to publish some notes or directions for the study of earthquakes, with special reference to those which occur in this country.

CHARLES DAVISON.

38 Charlotte Road, Birmingham, October 10.

### Effects of Lightning.

I HAVE known of the following case since July last, but owing to absence from this place have only been able to get particulars during the last few days.

During the terrific storm of the 12th of July last, a labourer's cottage was struck by lightning at Leagrave, near here. The lightning descended, according to an eye-witness's report, like a "spout of fire," and struck and descended the chimney, which it destroyed. In the room below there was an old shepherd, an invalid woman, a child, and a shepherd's dog. The shepherd was sitting in a chair leaning on a stick, a kettle was boiling on the fire, and the door was open. The lightning entered the room simultaneously by the chimney and an adjoining window. The window was utterly destroyed, and the kettle was thrown from the fire across the room, the stick on which the shepherd was leaning was torn from his hand and also thrown across the room, the lightning entered a cupboard containing glass and crockery and destroyed every article, and plaster was torn from the walls. The man and woman remained unhurt, but the child was thrown down and its knees stiffened. The dog was struck perfectly stiff, "like a log of wood," and was considered dead. The room seemed full of fire, water, and sulphur, and the occupants said the smell of sulphur was so strong that they would certainly have been suffocated had it not been for the open door. After the storm had abated, the dog, with all its limbs stiff, was laid in a barn, where it very slowly and partially recovered. It long remained both deaf and blind, and I was entirely dependent upon smell for its recognition of persons and things. To the present day it has not entirely recovered its injured senses.

Dunstable.

W. G. S.

### Electrical Cloud Phenomenon.

A SHORT description of a curious cloud appearance observed by me this summer may be of interest to your readers. It was noticed in Kiushu, the southernmost of the three great islands of Japan, early in July, at a distance of ten or twelve miles from the sea.

The season had been, and was, after the time of the observation, an exceptionally rainy one, severe floods being produced in almost all parts of the country, but it was not raining in the place where I made the observation at that particular time. Time shortly after midday, thermometer about 83° F.

The sky was clear overhead, but there was a great bank of heavy "thunderous" looking clouds to the south. It is most difficult to judge even approximately of the distance of clouds, but these might be from one to two miles off; the lower edge was represented by a very nearly straight line, and there was an amount of blue sky visible under the clouds that would perhaps subdivide from 10° to 15°.

My attention was attracted to a sort of "tail" of cloud stretching itself downwards from the straight under side of the cloud-bank. It gradually extended till it reached some two-thirds of the distance from the cloud to the earth. It remained of about constant length for a little over ten minutes, the lower end continually waving about in a most curious way, giving the impression almost that it was feeling for something.

Quite suddenly the filament of cloud straightened itself out, and extended itself towards the earth. The lower end became so very thin that, from the distance, it was impossible to see whether it actually made contact with the earth or not, but I have not the smallest doubt that it did, and that a silent discharge took place at the time. There was certainly no sound heard. Immediately after the contact the filament rapidly drew itself up to the cloud, and was incorporated with it. Almost immediately after this, whether as a mere coincidence or not I cannot tell, the cloud discharged a great amount of rain.

W. K. BURTON.

Imperial University, Tokio, Japan.

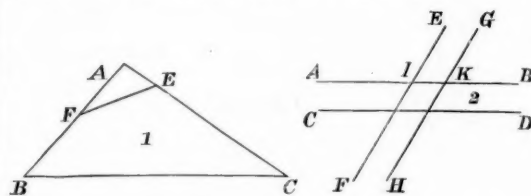
P.S.—The appearance was not unlike the illustrations of "water-spouts" that I have seen, but there was no whirling motion such as is always described as accompanying these, nor, indeed, was there any evidence of violent disturbance of any kind at all.

### The Use of the Word Antiparallel.

THE following note on the use of the word antiparallel may prove of interest to the readers of NATURE.

In the second edition of "A New Mathematical Dictionary" by E. Stone, F.R.S. (London, 1743), appears a short article on antiparallels, the whole of which I will quote:—

"Antiparallels, are those lines, as FE, BC, that make the same angles AFE, ACB, with the two lines AB, AC, cutting them, but contrary ways, as parallel lines that cut them. But Mr. Leibnitz, in the *Acta Erudit.*, An. 1691, p. 279, calls antiparallels those lines (see Fig. 2) as EF, GH, which cut two parallels AB, CD; so that the outward angle AIF, together with the inward angle AKH, is equal to a right angle. When



the sides AB, AC, of a triangle, as ABC (Fig. 1), are cut by a line EF antiparallel to the base BC, the said sides are cut reciprocally proportional by the said line EF; that is,  $AF : BF :: EC : AC$ , the triangles AFE, ABC being similar or equiangular."

The error in regard to the ratios of the segments of the sides is the same as the one noted in Hutton's "Miscellanea Mathematica," as quoted by Mr. Langley. I have no doubt that earlier instances of the use of this word can be found, and I would like to know whether the word is used in the first edition of "Stone's Dictionary."

W. J. JAMES.

Wesleyan University, Middletown,  
Conn. U.S.A., October 15.

### Fossil Rhizocarps.

IN Bennet and Murray's "Cryptogamic Botany," at p. 115, I am surprised to find in a reference to my paper on "Fossil Rhizocarps" (in *Bull. Ac. Sciences, Chicago*) the statement, with reference to the macrospores of *Protosiphonia*, that "inasmuch as they are borne on *Lepidodendron* scales this reference is inadmissible." Now no such fact has come to my knowledge, and on the contrary these bodies are found inclosed in cellular sporocarps like those of *Salvinia*, and are so described in the paper in question. If anyone has found them on "scales of *Lepidodendron*," the authority should have been stated.

Montreal, October 15.

J. WM. DAWSON.

### Specific Inductive Capacity.

ON p. 669 of Gano's "Physics" (eleventh edition) the following statement is found:—"At a fixed distance above a gold-leaf electroscope, let an electrified sphere be placed, by which a certain divergence of the leaves is produced. If now, the charges remaining the same, a disk of sulphur or of shellac be interposed, the divergence increases, showing that inductive action takes place through the sulphur to a greater extent than through a layer of air of the same thickness."

If this statement were correct, there should be less electric action on the side of the ball furthest from the electroscope when the dielectric is interposed. To test this I arranged an experiment as follows:—

The knob of a charged Leyden jar was placed midway between two insulated plates of metal, each plate being in connection with an electroscope. The leaves of each electroscope now diverged to an equal extent.

A plate of ebonite was now placed between the knob of the jar and one of the plates. If the statement above quoted is

correct, the leaves of the electroscope in connection with this plate should show an increased divergence, but the reverse effect was observed. *The leaves partially collapsed.* In all experiments that I have made by inserting dielectrics between a charged body and an electroscope, less electric action has been the result. If while the charged ball be near the electroscope the plate of it be touched with the finger, the leaves collapse, and on removing the finger and then the charged ball they again diverge.

Now let a dielectric be placed between the ball and the electroscope, touch the latter, and remove the finger and ball as before, and much greater divergence will be produced. In both cases the electroscope is charged by induction. Without putting the electroscope to earth, I fail to see theoretically why any greater divergence should occur. I suppose someone must have made the experiment as quoted, but if a greater effect was produced it must have been caused by the substance used for a dielectric being charged itself. I have found very great difficulty in preventing plates of ebonite, paraffin, sulphur, &c., becoming electrified when placed near a charged body.

I should like to know if anyone has experimented in this direction, because either the text-books or myself must be wrong. In Guthrie's book (p. 101) there is a statement similar to Ganot's.

W. A. RUDGE.

#### Who discovered the Teeth in Ornithorhynchus?

ON returning from Central Arizona, where I have been engaged in biological explorations, I find upon my desk an important paper entitled "On the Dentition of Ornithorhynchus," by my friend Mr. Oldfield Thomas, Curator of Mammals in the British Museum (see Proc. Royal Soc., vol. xli, 1889, 126-131, pl. 2).

The opening sentence of this paper is as follows: "At the meeting of the 9th of February, 1888, Mr. E. B. Poulton communicated to this Society the first discovery of the presence of teeth in *Ornithorhynchus*, a discovery which naturally awakened extreme interest throughout the scientific world." A few lines further on Mr. Thomas continues: "The grand fact of the presence of teeth in Monotremes, and their mammalian nature, are discoveries on which Mr. Poulton may well be congratulated."

From the above I infer that considerable stir has been made by the assumed new "discovery" that the young *Ornithorhynchus* has teeth.

If my British colleagues will turn to the masterly work of their illustrious countryman, Sir Everard Home, they will find in the second volume of his "Lectures on Comparative Anatomy" (published in 1814), no less than three beautifully engraved plates, containing eight figures, of the skull and mouth parts of *Ornithorhynchus*. Four of these figures show the teeth—two on each side of each jaw. The explanation accompanying Fig. 1, Tab. lix., is as follows: "A view of the upper jaw and palate, to show that there are two grinding teeth on each side." Fig. 2 is "a similar view of the under jaw."

Washington, D.C., October 12.

C. HART MERRIAM.

#### ON THE HARDENING AND TEMPERING OF STEEL.<sup>1</sup>

##### I.

THE fact that the British Association meets this year at Newcastle no doubt suggested to the Council that it would be well to provide, for the first time since 1848, a lecture on a metallurgical subject. In that year a discourse was delivered at Swansea by Dr. Percy, one of the most learned metallurgists of our time, who has recently passed away, after having almost created an English literature of metallurgy by the publication of his well-known treatises, without which it would have been comparatively barren. It was to him that the country turned in 1851 when it became evident that our metallurgists must receive scientific training.

I know that it has occurred to many that the various problems involved in the "hardening and tempering of steel" must be incapable of adequate treatment in the brief limits of a discourse like this, while others will think

that the details of the process, which is practised daily in thousands of workshops, are so well known that it is unnecessary to devote a lecture to the subject. It seemed to me that the entire question was the most important I could choose, partly because it will enable a large number of people who are engaged in industrial work, and who are not expected to think about it in a scientific way, to know how such facts as we shall have to examine have been dealt with by scientific investigators; while those of our members who do not consider that their thoughts or work are scientific in its strictest sense, may perhaps be interested to see how absolutely industrial progress depends upon the advancement of science. This consideration has led me to deal with the subject in a somewhat comprehensive way. The treatment of iron in its several forms is the thing that we as a nation do well. If it be true that national virtues are manifestly expressed in the industrial art of a people, we may recall the sentence in Mr. Ruskin's "Crown of Wild Olive" in which he says, "You have at present in England only one art of any consequence—that is, iron-working," adding, with reference to the manufacture of armour-plate, "Do you think, on those iron plates your courage and endurance are not written for ever, not merely with an iron pen, but on iron parchment?" It may be well, therefore, to consider what properties iron possesses which entitle its application to industrial use to specially represent the skill and patience of the nation.

In 1853, Lord Armstrong, in his address as President of this Association, expressed the hope "that when the time again comes round to receive the British Association in this town, its members will find the interval to have been as fruitful as the corresponding period," since the previous meeting in 1838, "on which they were then looking back." In one way at least this hope has been realized, for the efforts of the last twenty years have resulted in the development of an "age of steel." When the Association last met here, steel was still an expensive material, although Bessemer had, seven years before, communicated his great invention to the world through the British Association at its Cheltenham meeting. The great future in store for Siemens's regenerative furnace, which plays so important a part in the manufacture of steel, was confidently predicted in his Presidential address by Lord Armstrong, than whom no one was better able to judge, for no one had done more to develop the use of steel of all kinds.

Steel, we shall see, is modified iron. The name iron is in fact a comprehensive one, for the mechanical behaviour of the metal is so singularly changed by influences acting from within and without its mass, as to lead many to think, with Paracelsus, that iron and steel must be two distinct metals, their properties being so different. Pure iron may be prepared in a form as pliable and soft as copper, steel can readily be made sufficiently hard to cut glass, and notwithstanding this extraordinary variance in the physical properties of iron and certain kinds of steel, the chemical difference between them is comparatively very small, and would hardly secure attention if it were not for the importance of the results to which it gives rise. We have to consider the nature of the transformations which iron can sustain, and to see how it differs from steel, of which an old writer has said,<sup>1</sup> "Its most useful and advantageous property is that of becoming extremely hard when ignited and plunged into cold water, the hardness produced being greater in proportion as the steel is hotter and the water colder. The colours which appear on the surface of steel slowly heated direct the artist in tempering or reducing the hardness of steel to any determinate standard." There is still so much confusion between the words "temper," "tempering," and "hardening," in the writings of even very eminent authorities, that it is well

<sup>1</sup> A Lecture delivered on September 13, by Prof. W. C. Roberts-Austen, F.R.S., before the members of the British Association.

<sup>2</sup> "The First Principles of Chemistry," by V. Nicholson, p. 312 (London, 1790).



to keep these old definitions carefully in mind. I shall employ the word tempering in the sense of softening, as Falstaff uses it when he says of Shallow :—

"I have him already tempering between my finger and my thumb, and shortly will I seal with him."<sup>1</sup>

softening, that is, as brittle wax does by the application of gentle heat. *Hardening*, then, is the result of rapidly cooling a strongly heated mass of steel. *Tempering* consists in re-heating the hardened steel to a temperature far short of that to which it was raised before hardening: this heating may or may not be followed by rapid cooling. *Annealing* consists in heating the mass to a temperature higher than that used for tempering, and allowing it to cool slowly.

First, let the prominent facts be demonstrated experimentally.

[Three sword-blades of identical quality, made by an eminent sword-smith, Mr. Wilkinson, were taken. It was shown by bending one that it was soft; this was heated to redness and plunged into cold water, when it became so hard that it broke on the attempt to bend it. Another was bent into a bow, the arc of which was four inches shorter than the sword itself, a common test for "temper," and it sprang back to a straight line when the bending force was removed; this had been tempered. A third, which had been softened by being cooled slowly, bent easily and remained distorted.]

The metal has been singularly altered in its properties by comparatively simple treatment, and all these changes it must be remembered have been produced in a solid metal to which nothing has been added, and from which nothing material has been taken. The theory of this operation which I have just conducted has been laboriously built up, and its consideration introduces many questions of great interest both in the history of science, and in our knowledge of molecular physics. First as regards the history of the subject. The knowledge that steel might be hardened must have come to us from remote antiquity. Copper hardened with tin was its only predecessor, and it continued to be used very long after it was known that steel might be hardened. It would, moreover, appear that a desire to appreciate the difficulties of a people to whom cutting instruments of hard steel were unknown, seems to have induced experimenters in quite recent times to fashion implements of bronze, and a trustworthy authority tells us that "Sir Francis Chantry formed an alloy containing about 16 parts of copper, 2½ of zinc, and 2½ of tin, of which he had a razor made, and I believe even shaved with it."<sup>2</sup> The Greek alchemical manuscripts which have been so carefully examined by M. Berthelot give various receipts from which it is evident that in the early days the nature of the quenching fluid was considered to be all-important. There were certain rivers the waters of which were supposed to be specially efficacious. Pliny, who says that the difference between waters of various rivers can be recognized by workers in steel, also knew that oil might be used with advantage for hardening certain varieties of the metal. It is sad to think how many of the old receipts for hardening and tempering have been lost. What would we not give, for instance, for the records of the Gallic prototype of our Iron and Steel Institute, the "*Collegium Fabrorum Ferrariorum*,"<sup>3</sup> a guild with similar aims, formed in the time of the Roman Republic, for the advancement of knowledge, for the good of the State, and not for that of its individual members? The belief, however, in the efficacy of curious nostrums and solutions for hardening steel could hardly have been firmer at any period than in the sixteenth century of our era. Shake-

speare suggests that Othello's sword "of Spain" had been hardened in a cold stream for he says it had

"the ice brook's temper";

but cold water was far too simple a material for many a sixteenth century artificer to employ, as is shown by the quaint recipes contained in one of the earliest books of trade secrets, which, by its title, showed the existence of the belief that the "right use of alchemy" was to bring chemical knowledge to bear upon industry. The earliest edition was published in 1531,<sup>4</sup> and the first English translation<sup>5</sup> in 1583, from which the following extracts may be of interest. "Take snayles, and first drawne water of a red die of which water being taken in the two firste moneths of haruest when it raynes," boil it with the snails, "then heate your iron red hote and quench it therein and it shall be hard as steele." "Ye may do the like with the blood of a man of xxx yerres of age, and of sanguine complexion, being of a merry nature and pleasaunt . . . distilled in the middst of May." This may seem trivial enough, but the belief in the efficacy of such solutions survived into the present century, for I find in a work published in 1810 that the artist is prettily directed<sup>6</sup> "to take the root of blue lilies, infuse it in wine and quench the steel in it," and the steel will be hard; on the other hand, he is told that if he "takes the juice or water of common beans and quenches iron or steel in it, it will be soft as lead." I am at a loss to explain the confusion which has arisen from this source. As must always be the case when the practice of an art is purely empirical, such procedure was often fantastic, but it is by no means obsolete, for probably at the present day there is hardly a workshop in which some artificer could not be found with a claim to possess a quaint nostrum for hardening steel. Even the use of absurdly compounded baths, to which I have referred, was supported by theoretical views. Otto Tachen,<sup>4</sup> for instance, writing of steel in about the year 1666, says that steel when it is "quenched in water acquires strength because the light alcaly in the water is a true comforter of the light acid in the iron, and cutlers do strengthen it with the alcaly of animals," hence the use of snails. Again, Lemery<sup>5</sup> explains in much the same way the production of steel by heating iron in the presence of horns of animals.

I have dwelt so long on these points in order to bring out clearly the fact that the early workers attached great importance to the nature of the fluid in which hot steel was quenched, and they were right, though their theories may have been wrong. The degree of rapidity with which heat is abstracted from the steel during the operation of hardening is as important at the present day as it ever was. Roughly speaking, if steel has to be made glass-hard, ice-cold water, brine, or mercury, is used; if it has only to be made slightly hard, hot water or oil may be employed; while, as Thomas Gill<sup>6</sup> suggested in 1818, both "hardening" and "tempering" may be united in a single operation by plunging the hot metal in a bath of molten lead or other suitable metal, which will of course abstract the heat more slowly.

We must now trace the development of theories relating to the internal constitution of steel. The advent of the phlogistic school with the teaching of Becher and Stahl led to the view that iron gained phlogiston during its conversion into steel. By phlogiston we know that the early chemists really meant *energy*, but to them phlogiston was represented to be a kind of soul possessed by all metals,

<sup>1</sup> "Rechter Gebrauch d. Alchimei," 1531. There were many English editions.

<sup>2</sup> "A profitable booke declaring dyers approued remedies," &c. (London, 1583). See Prof. Ferguson's learned paper "On some Early Treatises on Technological Chemistry," Phil. Soc., Glasgow, January 1886.

<sup>3</sup> "The Laboratory or School of Arts," 6th edition, 1799, p. 228. There is a later edition of 1810.

<sup>4</sup> "His Key to the Ancient Hippocratical Learning," p. 68 (London, 1690).

<sup>5</sup> "A Course of Chemistry," 2nd edition, 1686, p. 131.

<sup>6</sup> Thomson's *Annals of Philo. ophy*, xii., 1818, p. 58.

<sup>1</sup> King Henry IV., Part II., Act iv., Scene 3.

<sup>2</sup> "Engines of War," by H. Wilkinson, p. 194 (1841).

<sup>3</sup> "La Ferronnerie," par F. Liger, t. ii. p. 147 (Paris, 1875).



which they could lose by burning and regain by the process they called "revivification." "Hardness [in metals] is caused by the jeuneness of the spirit and their impurity with the tangible parts," said Francis Bacon;<sup>1</sup> while, according to Stahl,<sup>2</sup> steel was merely iron possessing, in virtue of its phlogiston, the characteristics of a metal in a higher degree; and this view prevails in the writings of Henckel, Newmann, Cramer, Gellert, Rinman, and Macquer. This opinion survived with wonderful persistence, but it did not influence the teaching of Réaumur,<sup>3</sup> who, in 1722, was, so far as I know, the first to suggest a physical theory which has been in any way justified by modern research. He assumed that when steel was heated "sulphurs and salts" were driven out from the molecules, which he represents diagrammatically, into the interstitial space between them. The quenching of the steel and its sudden cooling prevented the sulphurs and salts from returning into the molecules, which were thus firmly cemented by the matter between them, and hard rigid steel was the result. In tempering, the sulphurs and salts partially returned into the molecules, and the metal became proportionately soft. I have elsewhere shown<sup>4</sup> that he used the Torricellian vacuum to demonstrate that the hardening of steel is not accompanied by the evolution of gas, and he concluded that "since the hardening of steel is neither due to the intervention of a new substance nor to the expulsion of air, it only remains to seek its cause in the changes occurring in its structure." Notwithstanding this, the phlogistic school were not daunted, and this brings me to the work of Torbern Bergman, the great Professor at the University of Upsala, who in 1781 showed<sup>5</sup> that steel mainly differs from iron by containing about  $\frac{1}{10}$  per cent. of plumbago, while iron does not. Read in connection with modern research, his work seems wonderfully advanced. He was so forcibly impressed by the fact that the great difference in the mechanical properties of different specimens of iron is due to the presence of small quantities of impurity, and that the properties of iron do not vary, as he says, unless by chance the iron has gathered foreign matter, "*nisi forte peregrinum paullo uberius inharat metallum*." We find, even, the dawn of the view that under the influence of small quantities of foreign matter iron is, as he calls it, polymorphous, and plays the part of many metals. "*Adeo ut jure dici queat, polymorphum ferrum plurimum simul metallorum vices sustinere*."<sup>6</sup> Unfortunately he confounded the plumbago or carbon he had isolated with phlogiston, as did Rinman in 1782, which was strange, because, in 1774, the latter physicist had shown that a drop of nitric acid simply whitens wrought iron, but leaves a black stain on steel. Bergman tenaciously held to the phlogistic theory in relation to steel; it was inevitable that he should. The true nature of oxidation had been explained; no wonder that the defenders of the phlogistic theory should seek to support their case by appealing to the subtle and obscure changes produced in iron by such apparently slight causes. Bergman's view was, however, combated by Vandermonde, Berthollet, and Monge,<sup>7</sup> who showed in a report communicated to the Académie des Sciences, in 1786, that the difference between the main varieties of iron is determined by variation in the amount of carbon, and further that steel must contain a certain quantity of carbon in order that it might possess definite qualities. Bergman died in 1784, and the report to which I have referred is full of respect for "this

grand chemist," as its authors call him, "whom science had lost too soon."

Kirwan's essay on phlogiston,<sup>1</sup> in which Bergman's views were defended, elicited a reply from Lavoisier himself, and brought down the French school in strength to contest almost the last position occupied by the believers in phlogiston.<sup>2</sup>

An entire lecture might be profitably devoted to Bergman's work. His was almost the first calorimetric research, and is specially interesting when taken in connection with the calorimetric investigations of Lavoisier and Laplace in 1780, and it is impossible to read it without feeling that in paying the just tribute to Lavoisier's genius Bergman has been overlooked. He desired to ascertain whether pure iron, steel, and cast iron contain the same amount of heat. He therefore attacked the materials with a solvent, and noted the heat evolved. He says the solvent breaks up the assemblage of the aggregation of molecules and forms other unions. If the new body demands more heat than the body which has been disunited, then the thermometer will fall. If, on the other hand, the degree of heat required is less, the environment will be heated, which will result in the rise of the thermometer. The modern development is that, when a chemical compound is formed, heat is evolved and energy is lost, but if one substance, say a metal, simply dissolves another, the solution is attended with absorption of heat, and the product when attacked by a suitable solvent should evolve practically the same amount of heat, but certainly not less than would be evolved by the individual metals present in solution.<sup>3</sup> This is specially interesting from its relation to the calorimetric work of Lavoisier and Laplace in 1780 and of Lavoisier in 1782, which led the latter to explain the nature of oxidation, and to show that a metal could be as truly "calcined" or oxidized by the action of a solution as by the action of air at an elevated temperature. Now that the importance of thermochemistry is beginning to be recognized in relation to industrial chemistry and metallurgy, it is to be hoped that Bergman's merits will be more fully considered. We are, however, mainly concerned with the fact that he taught us that the difference between iron and steel consists in the  $\frac{1}{10}$  to  $\frac{1}{12}$  per cent. of carbon which steel contains. It was only natural that Black, writing in 1796, should have attributed the hardening of steel to the "extrication of latent heat"; "the abatement of the hardness by the temper" being due, he says, "to the restoration of a part of that heat."<sup>4</sup> Black failed to see that the work of Bergman had entirely changed the situation. The next step was made in France. It was considered necessary to establish the fact that carbon is really the element which gives steel its characteristic properties, and with this object in view, Clouet,<sup>5</sup> in 1798, melted a little crucible of iron, weighing 57.8 grammes, containing a diamond, weighing 0.907 gramme, and obtained a fused mass of steel (Fig. 1).

His experiment was repeated by many observers, but the results were open to doubt from the fact that furnace gases could always obtain access to the iron, and might, as well as the diamond, have yielded carbon to the metal.

<sup>1</sup> R. Kirwan, "Essay on Phlogiston and the Constitution of Acids," p. 134 (1787).

<sup>2</sup> "Essai sur le Phlogistique," traduit de l'Anglois de M. Kirwan, avec des notes de M. M. de Morveau, Lavoisier, de la Place, Monge, Berthollet, et de Fourcroy (Paris, 1788).

<sup>3</sup> See French translation of Bergman's work (Paris, 1783), p. 72. The question is, however, so important that I append the original Latin text:—"Menstruo laxatur compages molecularum, et nova formatur connubia, quæ, si majorem, quam diruta, figunt materiae caloris quantitatem, in vicinia calor ad restituendum æquilibrium diminuat oportet, et thermometri hydrargyrum ideo subsidet: si minorem, differentia liberatur et viciniam calefacit, unde etiam adscendit thermometri liquor; si denique nova connubia eandem præcise quantitatem possident, quod raro accidit, nulla in thermometro videbitur variatio."—Torbern Bergman, "Opuscula Physica et Chemica," vol. iii. p. 38, 1783 ("De Analysi Ferri").

<sup>4</sup> "Lectures on the Elements of Chemistry," vol. ii. p. 505 (1803).

<sup>5</sup> Experiment described by Guyton de Morveau, *Ann. de Chim.*, xxxi. 1799, p. 328.

<sup>1</sup> "Sylva Sylvarum," 2nd edition, 1628, p. 215.

<sup>2</sup> "Fundamenta Chæmiæ," Part 3, p. 451, quoted by Guyton de Morveau in the article "Acier," "Encyc. Méthodique," p. 421 (Paris, 1786).

<sup>3</sup> "L'art de convertir le fer forgé en acier," p. 321 et seq. (Paris, 1722).

<sup>4</sup> Proc. Inst. Mech. Engineers, October 1881, p. 706.

<sup>5</sup> "Opuscula Physica et Chemica," vol. iii. "De Analysi Ferri" (Upsala, 1783). A dissertation delivered June 9, 1781.

<sup>6</sup> "De Analysi Ferri," p. 4.

<sup>7</sup> "Histoire de l'Académie Royale des Sciences," 1786 (printed 1788), p. 132.

The carbon might have been presented to the iron in the form of a gas capable of yielding carbon, and this element would as surely have found its way into the steel.

Marguerite,<sup>1</sup> for instance, in 1865, repeated Clouet's experiment, and showed that, although carburization can be effected by simple contact of iron and carbon, it is nevertheless true that in the ordinary process of cementation the gas carbonic oxide plays an important part, which had until then been overlooked. The discovery by Graham,<sup>2</sup> in 1866, of the occlusion of carbonic oxide by

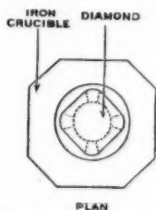


FIG. 1.—Plan of iron crucible and diamond from the drawing in Guyton de Merville's paper. In the original, the diamond and the crucible are drawn, in plan, separately.

iron, gave additional support to this theory. I am glad to remember that he trusted the experiments to me.

The question, however, of the direct carburization of iron by the diamond has never been doubted since 1815, when a working cutler, Mr. Pepys,<sup>3</sup> heated iron wire and diamond dust together and obtained steel, the heat being afforded by a powerful electric battery. I am anxious to make this absorption of carbon in the diamond form clear by this diagram (Fig. 2).

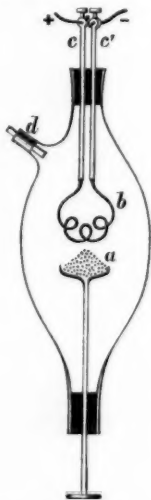


FIG. 2 represents a glass vessel which may either be rendered vacuum or may be filled with an atmosphere of gas through the tube *d*. An iron wire, *b*, placed between the terminals of a battery, *c, c'*, is heated to redness, and remains glowing until it is touched by pure diamond dust, which is effected by raising the cup *a*. The iron combines with the diamond dust and fuses.

Do not think for a moment that the steel owes its hardness to the passage of diamond into the iron, as diamond. I have repeated Marguerite's form of Clouet's experiment, using, however, a vacuum instead of an atmo-

sphere of gas, and employing the form of apparatus shown in this diagram (Fig. 3). [The carburized iron which was the result of the experiment was thrown upon the screen.] The diamond by union with iron has passed partially at least to the other form of carbon, graphite, while treatment with a solvent which removes the iron shows that carbon has entered into intimate association with the iron, a fact which leads us to the next step in the study of the relations between carbon and iron.

Hempel<sup>1</sup> has shown that, in an atmosphere of nitrogen, iron appears to assimilate the diamond form of carbon more readily than either the graphitic or the amorphous

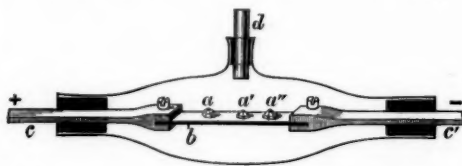


FIG. 3 represents an arrangement for heating the diamond and iron *in vacuo*. A strip of pure iron, *b*, is placed between two terminals, *c, c'*, which are connected with a dynamo. The vessel (of glass) is rendered vacuum by connecting the tube *d* with a Sprengel pump. The iron is then heated by the dynamo, and maintained glowing until all occluded gas is expelled from the iron, which is then allowed to cool *in vacuo*. Small pure diamonds, *a, a', a''*, are then placed on the strip of iron through the orifice into which the tube *d* fits. The vessel is rendered vacuum, and when the iron is again heated in contact with the diamonds it fuses and combines with them.

forms, but directly carbon is associated with *molten* iron it behaves like the protean element it is, and the state which this carbon assumes is influenced by the rate of cooling of the molten mass, or even by the thermal treatment to which the solidified mass is subjected. Let me repeat, all are familiar with carbon in the distinct forms of diamond, graphite, and soot: all are alike carbon. It need not be considered strange, then, that carbon should be capable of being present in intimate association with iron, but in very varied forms.

Now the mode of existence of carbon in soft annealed steel is very different from that in which it occurs in hard steel. I believe that Karsten was the first to isolate, in 1827, from soft steel a true compound of iron and carbon. Berthier<sup>2</sup> also separated from soft steel a carbide of iron, to which he assigned the formula  $\text{Fe}_3\text{C}$ ; but to attempt to trace the history of the work in this direction would demand an entire lecture. I will only add that within the last few years Sir F. Abel has given much experimental evidence in favour of the existence in soft cold rolled steel of a carbide,  $\text{Fe}_3\text{C}$ , which he isolated by the slow solvent action of a chromic acid solution. His work has been generally accepted as conclusive, and has been the starting-point of much that has followed.

It will occur to you that the microscope should reveal wide differences between the structure of various kinds of iron and steel, and I am happy to be able to give you enlarged diagrams made from the drawings of Mr. Sorby, the eminent microscopist, which illustrated his very delicate investigations into the structure of steel.<sup>3</sup>

The point I am mainly concerned with is the existence of a substance which Sorby called the "pearly constituent" in soft steel. This pearly constituent is closely related to the carbide of iron,  $\text{Fe}_3\text{C}$  of Abel,<sup>4</sup> and is probably a mixture of  $\text{Fe}_3\text{C}$  and pure iron. I have diagrammatically indicated its presence in Fig. 4, which will enable me to summarize the work of many experimenters. The diagram (Fig. 4) will serve, for the purpose of illustration,

<sup>1</sup> Ber. der deutsch. chem. Gesellschaft, vol. xviii. p. 998.

<sup>2</sup> Ann. des Mines, t. iii., 1833, p. 229.

<sup>3</sup> The reader must refer to the Journal of the Iron and Steel Institute, No. 1., 1887, 255.

<sup>4</sup> Proc. Inst. Mech. Engineers, January 1883.

<sup>1</sup> "Sur l'aciération," Ann. Chim. et Phys., t. vi. [4], 1865.

<sup>2</sup> Phil. Trans. Roy. Soc., 1866, pp. 399-439.

<sup>3</sup> Ibid., 1815, p. 371.

to indicate the appearance when soft, hardened, and tempered steel are respectively treated with a solvent which acts gently on the mass.

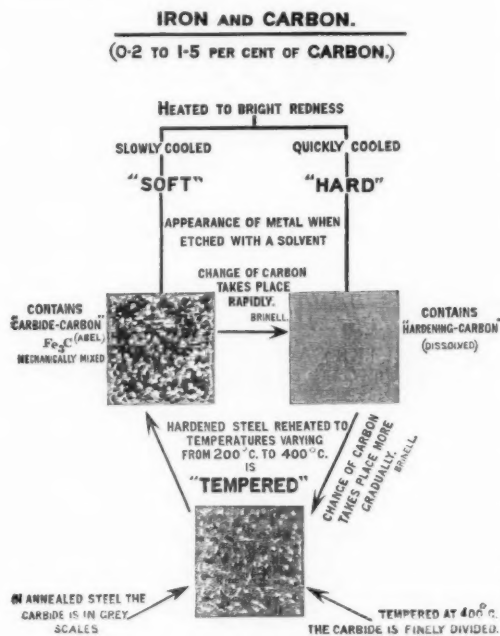


FIG. 4.

A study of the above diagram and of the admirable work of Ledebur<sup>1</sup> will show how complex the relations of carbon and iron really are, but, for the purposes of the present inquiry it may fairly be asked, Does a change in the "mode of existence" of carbon in iron sufficiently explain the main facts of hardening and tempering? It does not. It is possible to obtain by rapid cooling from a certain temperature steel which is perfectly soft, although analysis proves that the carbon is present in the form which we have recognized as "hardening carbon." No doubt in the hardening of steel the carbon changes its mode of existence, but we must seek some other theory to explain all the facts, and in order to do this we will turn to the behaviour of the iron itself.

In approaching this portion of the subject a few elementary facts relative to the constitution of matter must be recalled, and in doing so I must again appeal briefly to history. It is universally accepted that metals, like all elements, are composed of atoms of definite weights and volumes grouped in molecules. In order actually to transmute one metal into another it would be necessary to discover a method of attacking not the molecule but the *atom*, and of changing it, and this, so far as is known, has not yet been done; but it is possible, by influences which often appear to be very slight, to change the relations of the molecules to each other, and to alter the arrangements or distribution of the *atoms* within the *molecules*, and by varying in this sense the molecular arrangement of certain elements, they may be made to pass into forms which are very different from those in which we ordinarily know them. Carbon, for instance, when free, or when associated with iron, may readily be changed from the diamond to the graphitic

form, though the converse change has not as yet been effected.

Sulphur, again, with which you are familiar as a hard, brittle, yellow solid, may be prepared and maintained for a little time in the form of this brown viscous mass, but this latter form of sulphur soon passes spontaneously and slowly at the ordinary temperature, and instantaneously at 100°, to the solid octahedral yellow modification with evolution of heat. The viscous form of sulphur is an allotropic modification of that element. A few cases of allotropy in metals have already been established, and when they do occur they give rise to problems of vast industrial importance. Such molecular changes in metals are usually produced by the addition of a small quantity of foreign matter, and I have elsewhere tried to show that the molecular change produced by the action of *traces* upon *masses* is a wide-spread principle of nature, and one which was recognized at the dawn of the science of chemistry, even in the seventh century, although distorted explanations were given of well-known facts, and gave rise to entirely false hopes. But it is the same story now as in mediæval times: the single grain of powder which Raymond Lully said would transmute millions of its weight of lead into gold—the single grain of stone that Solomon Trismosin thought would secure perpetual youth—had their analogues in the small amount of plumbago which, to Bergman's astonishment in the eighteenth century, converted iron into steel. By his time it was recognized that the right use of alchemy consisted in the application of its methods to industry, and we still wonder at the minuteness of the quantity of certain elements which can profoundly affect the properties of metals. The statements are true, and are not derived from poetical literature, early or late. Even in the moral world the significance of the action of traces upon masses has been recognized, and the method of the alchemist survives in the administration of the small quantity of powder which, in the imagination of Robert Louis Stevenson, will produce the malevolent Hyde modification of the benevolent Dr. Jekyll. In thus borrowing an illustration from one of the most refined and subtle writers of our time, I do not fear the taunt of Francis Bacon,<sup>2</sup> that "sottishly do the chymics appropriate the fancies and delights of poets in the transformation of bodies to the experiments of their furnaces;" for, although it may not be possible to *transmute* metals, it is easy so to *transform* them, by very slight influences, that as regards special service required from them they may behave either usefully or entirely prejudicially.

In attempting to illustrate this part of the subject I cannot take the most striking cases, as it is difficult to demonstrate them in the time at my disposal. The following experiment, which does not, however, depend upon the action of a trace upon a mass, will enable me to lead up to the point I wish to insist upon. It consists in the release of gold from its alloy with potassium. When the alloy is treated with water, the gold comes down in a finely divided, dark brown, chemically active state. [Experiment shown on the screen.]

I have chosen this experiment because it was a similar one that first roused suspicion that pure iron could exist in more than one form.

The question at once suggests itself, Can iron behave in a similar manner: is an allotropic form of iron known? Joule afforded experimental evidence for an affirmative answer to this question nearly forty years ago by communicating to the British Association in 1850 a paper on some amalgams. The result of his experiments, published in detail later,<sup>3</sup> in a paper which has been sadly neglected, showed that iron released from its amalgam with mercury is chemically active, as it com-

<sup>1</sup> Preface to the "Wisdom of the Ancients."

<sup>2</sup> "On some Amalgams," Mem. Lit. Phil. Soc. Manchester, vol. ii. [3], p. 115.

<sup>3</sup> *Stahl und Eisen*, vol. viii., 1883, p. 742.

bines readily with the oxygen of the air at the ordinary temperature, and he claims that the iron so set free is allotropic; but Joule did much more than this. Magnus had shown (1851) that the thermo-electric properties of hard and soft steel and iron differ. Joule, in a paper on some thermo-electric properties of solids, incidentally shows that the generation of a thermo-electric current affords a method of ascertaining the degree of carburization of iron, and he appeals to the "thermo-electricity of iron in different states" as presenting a "fresh illustration of the extraordinary physical changes produced in iron by its conversion into steel," and he adds the expression of the belief "that the excellence of the latter metal might be tested by ascertaining the amount of change in thermo-electric condition which can be produced by the process of hardening."<sup>1</sup> It is by a thermo-electric method that the views as to the existence of iron in allotropic forms has been confirmed. Jullien seems to have inclined to the view that iron is allotropic in his "Théorie de la Trempe,"<sup>2</sup> published in 1865, but he cannot be said to have added much to our knowledge, although he certainly directed attention to the importance of hardening and tempering steel.

The next step was made in Russia, in 1868. Chernoff, who has found an admirable exponent to English readers in Mr. W. Anderson, President of Section G, showed that steel could not be hardened by rapid cooling until it had been heated to a definite temperature—to a degree of redness which he called *a*. Then in 1873, Prof. Tait<sup>3</sup> used this expression in a Rede Lecture delivered at Cambridge: "It seems as if iron becomes, as it were, a different metal on being raised above a certain temperature; this may possibly have some connection with the ferricum and ferrosium of the chemists." He also published his now well-known "first approximation to a thermo-electric diagram," which is of great interest in view of recent work. At about this time those specially interested in this question remembered that Gore<sup>4</sup> had shown that a curious molecular change could be produced by heating an iron wire, which sustains a momentary elongation on cooling. Barrett repeated Gore's experiment, and discovered that as an iron wire cools down it suddenly *glows*, a phenomenon to which he gave the name *recalcescence*, and these investigations have been pursued and developed in other directions by many skilful experimenters.<sup>5</sup> In 1879, Wrightson<sup>6</sup> called attention to the abnormal expansion of carburized iron at high temperatures.

The next point of special importance seems to me to be that recorded by Barus, who, by a thermo-electric method, showed, in an elaborate paper published in 1879,<sup>7</sup> that "the hardness of steel does not increase continuously with its temperature at the moment of sudden cooling, but at a point lying in the dark-red heat the glass-hard state" may suddenly be attained by rapid cooling. I shall have again to refer to the remarkable series of papers published by Barus and Strouhal,<sup>8</sup> embodying the results of laborious

investigations, to which, in the limited space of this lecture, I can do but scanty justice; and finally, within the last few years, Pionchon<sup>1</sup> showed that at a temperature of 700° the specific heat of iron is altogether exceptional, and Le Chatelier<sup>2</sup> has detected that at the same temperature a change occurs in the curve representing the electromotive force of iron—both experimenters concluding that they had obtained evidence of the passage of iron into an allotropic state.

Osmond,<sup>3</sup> in France, then made the observations of Gore and Barrett the starting-point of a fresh inquiry, which will now be considered at some length, as Osmond has arrived at conclusions of much interest and importance.

(To be continued.)

#### ON A NEW APPLICATION OF PHOTOGRAPHY TO THE DEMONSTRATION OF CERTAIN PHYSIOLOGICAL PROCESSES IN PLANTS.

MR. WALTER GARDINER, Lecturer on Botany in the University of Cambridge, who delivered the evening address at Newcastle on "How Plants maintain themselves in the Struggle for Existence," has discovered a new method of printing photographic negatives, employing living leaves in place of sensitive paper. Mr. Gardiner read a paper on the subject before the British Association. Before dealing with the immediate subject of his paper, the author described how prints may be obtained from *Proto-cocci*, or the free-swimming swarm-spores of many green Algae. It is possible to take advantage of their sensitiveness to light. Into one end of a water-tight box, a thin glass plate is securely fitted. The negative to be printed is then placed next the glass, film side nearest. The box is filled with water containing a fairly large quantity of swarm-spores. The lid is shut down, and the whole is exposed to diffused light. In the case of a strong and well-developed negative, the swarm-spores swim towards the most highly-illuminated parts, and there in the greatest numbers come to rest, and settle upon the glass, so that, after some four or six hours, on pouring out the water and removing the negative, a print in green swarm-spores can be obtained. The print may be dried, fixed with albumen, stained, and varnished. The author then dwelt upon the well-known fact that the whole of the animal life upon the globe depends directly or indirectly upon the wonderful synthetic formation of proteid and protoplasm which takes place in the living tissue of plants containing chlorophyll, *i.e.* green plants, or, to be more exact, in the green chlorophyll corpuscles. He stated that, whatever is the exact chemical nature of the process, this is at least clear, that the first *visible* product of the assimilatory activity is starch, which, moreover, is found in the chlorophyll grains. The presence of this starch can be made manifest by treating a decolorized leaf with a water solution of iodine dissolved in potassic iodide. This formation of starch only takes place under the influence of light; the radiant energy of the sun providing the means of executing the profound synthetic chemical change, and building up proteid from the carbonic acid of the air which is taken up by the leaves and the salts and water of the soil absorbed by the roots. If a plant (and preferably a plant with thin leaves) be placed in the dark over-night, and then brought out into the light next morning, the desired leaves being covered with a sharp and well-developed negative, starch is formed

<sup>1</sup> Phil. Trans., cxlix., 1859, p. 91.

<sup>2</sup> "Année au traité de la Métallurgie du Fer," 1865.

<sup>3</sup> NATURE, viii., 1873, pp. 86, 122; and Trans. Roy. Soc. Edin., xxvii., 1873, p. 125.

<sup>4</sup> Proc. Roy. Soc., xvii., 1869, p. 263.

<sup>5</sup> G. Forbes, Proc. Roy. Soc. Edin., viii., 1874, 363; Norris, Proc. Roy. Soc., xxvi., 1877, 127; Tomlinson, Phil. Mag., xxiv., 1887, 256; xxv., pp. 42, 105, and 372; xxvi., p. 18; Newall, Phil. Mag., xxiv., 1887, 435; xxv., 1888, p. 510.

<sup>6</sup> Journ. Iron and Steel Inst., No. ii. 1879; No. i. 1880.

<sup>7</sup> Barus, Phil. Mag., viii., 1879, p. 347.

<sup>8</sup> "Hardness (Temper), its Electrical and other Characteristics," Barus, Phil. Mag., viii. p. 347, 1879; Wied. Ann., vii. p. 383, 1879; Strouhal and Barus, Wied. Ann., xi. p. 930, 1880; *ibid.*, xx. p. 525, 1883; "Hardness and Magnetization," Wied. Ann., xx. pp. 537, 662, 1883; "Density and (Internal) Structure of Hard Steel and of Quenched Glass," Barus and Strouhal, American Journ., xxxi. p. 386, 1886; *ibid.*, p. 429; *ibid.*, xxxi. p. 181, 1886. "Temper and Chemical Composition," Am. Journ., xxxii. p. 276, 1886. "Temper and Viscosity," Am. Journ., xxxii. p. 444, 1886; *ibid.*, xxxiii. p. 20, 1887; Barus, *ibid.*, xxxiv. p. 1, 1887; *ibid.*, xxxiv. p. 175, 1887. These papers, systematically discussed and enlarged, are embodied with new matter in the *Bulletins* of the United States Geological Survey, viz. *Bull.*, No. 14, pp. 1-226, 1885; *Bull.*, No. 27, pp. 10-61, 1886; *Bull.*, No. 33, pp. 11-60, 1886; *Bull.*, No. 42, pp. 98-131, 1887.

<sup>1</sup> *Comptes rendus*, cli., 1886, pp. 675 and 1454, clii. p. 1122.

<sup>2</sup> *Ibid.*, cli. p. 819.

<sup>3</sup> The reader will find the principal part of Osmond's work in the following papers: Osmond et Werth, "Théorie Cellulaire des Propriétés de l'Acier," *Ann. des Mines*, viii., 1885, p. 5; "Transformations du Fer et du Carbone," Paris, Baudoin et Cie., 1888; "Études Métallurgiques," *Ann. des Mines*, Juillet-Août, 1888. There is also a very interesting paper, "Sur les Nouveaux Procédés de Trempe," which he communicated to the Mining and Metallurgical Congress, Paris, 1889.



when light is transmitted, and in greatest quantity in the brightest areas. Thus a positive in starch is produced which can be developed by suitable treatment with iodine. [A leaf was then developed, and handed round to the audience for inspection.] The author showed that it might be possible to obtain a permanent print by suitable washing and treatment with a soluble silver salt, silver iodide being formed. The author regards this discovery as a most striking illustration of the way in which plants are working for themselves, and so for all living things, and points out that the extraordinary manner in which the green parts of plants (so to speak) catch the radiant energy of the sun, and employ it for analytical and synthetical chemical processes, may be easily and clearly demonstrated.

#### NOTES.

WE understand that the late Mr. John Ball, F.R.S., has bequeathed his botanical library and herbarium to Sir Joseph Hooker, to the Director of the Royal Botanic Gardens at Kew for the time being, and to the President of the Royal Society for the time being, requesting them to give the same to such person or persons or public institution in this country, the British colonies, or elsewhere in the world, as they or any two of them may select, with the sole object of promoting the knowledge of natural science. Right is, however, reserved for Kew to select previously such specimens or books as it may want.

THE following is the list of names recommended by the President and Council of the Royal Society for election into the Council for the year 1890, at the forthcoming anniversary meeting on the 30th inst.:—President: Sir George Gabriel Stokes, Bart. Treasurer: Dr. John Evans. Secretaries: Prof. Michael Foster, the Lord Rayleigh. Foreign Secretary: Dr. Archibald Geikie. Other Members of the Council: Prof. Henry Edward Armstrong, Prof. William Edward Ayrton, Charles Baron Clarke, Prof. W. Boyd Dawkins, Dr. Edward Emanuel Klein, Prof. E. Ray Lankester, Dr. Hugo Müller, Prof. Alfred Newton, Captain Andrew Noble, C.B., Rev. Stephen Joseph Perry, Sir Henry E. Roscoe, Dr. Edward John Routh, William Scovell Savory, Prof. Joseph John Thomson, Prof. Alexander William Williamson, Colonel Sir Charles William Wilson, R.E.

IN the list of Englishmen decorated in connection with the British Section of the Paris Exhibition, the names of the following men of science are included:—Grand Officer of the Legion of Honour: Sir William Thomson, F.R.S. Officers of the Legion of Honour: Sir Douglas Galton, K.C.B., Sir Henry Roscoe, M.P., F.R.S., Mr. W. H. Preece, F.R.S. Chevaliers of the Legion of Honour: Prof. Francis Elgar, Prof. W. Roberts-Austen, F.R.S., Dr. C. Le Neve Foster. Officer of Public Instruction: Mr. C. V. Boys, F.R.S.

THE Naturforschende Gesellschaft at Emden is to celebrate its seventy-fifth anniversary on December 29 next. The Society was founded in 1814 by twenty-four burghesses of Emden. The festivities in December will consist of a general meeting of the Society and the Society's correspondents at noon in the Museum, and a *Festessen* at four o'clock.

A REPORT of the proceedings of the International Zoological Congress, held in Paris two months ago, will be published shortly.

A FRENCH translation of Dr. Wallace's "Darwinism" will be published next year.

THE greater part of the ethnographical collection sent to the Paris Exhibition is to remain in Paris, in the Colonial Museum.

THE following botanical appointments are announced:—The Directorship of the Botanic Garden at Berlin, vacant by the death of Dr. Eichler, having been conferred on Prof. Engler, of Breslau, Prof. Urban becomes Second Director of the Berlin Botanic Garden; and Prof. Prantl, of Aschaffenburg, succeeds Prof. Engler as Director of the Botanic Garden at Breslau. Prof. Sadebeck, of Hamburg, is appointed Director of the Botanic Garden in that town, in the place of the late Dr. Reichenbach. Dr. G. von Lagerheim vacates the Professorship at Lisbon, to which he was lately appointed, and goes to Ecuador as Professor of Botany and Director of the Botanic Garden at Quito. Dr. H. Molisch, of Vienna, takes the Chair of the late Dr. Leitgeb in the Polytechnic at Gratz. Dr. F. Hueppe is appointed Professor of Bacteriology at the University of Prague, and is succeeded in the same Chair at Wiesbaden by Dr. G. Frank, of Berlin. The venerable Professor von Naegeli retires from the Directorship of the Botanic Garden at Munich. Mr. F. S. Earle, Prof. E. S. Goff, and Prof. L. R. Taft have been appointed special agents in the Section of Vegetable Pathology of the United States Department of Agriculture. Mr. H. H. Rusby has been appointed Professor of Botany and Materia Medica in the New York College of Pharmacy.

THE Economic Museum, Calcutta, has completed and despatched the first instalment of important Indian fibres required by the India Office for presentation to the Museums of the Royal Botanical Gardens at Kew and Edinburgh, and to the Chambers of Commerce at Dundee and Manchester.

A PRIZE of about £20 is offered by the Geographical Societies of Dresden and Leipzig, for "a physico-geographical description of the course of the Elbe between Bodenbach and its entrance on the flat country, with special reference to depth, quantity of water and its variations, ice, and changes in the form of the banks." The date is the end of 1890.

IN his address at the opening of the winter session of the University of Toronto, Sir Daniel Wilson, the President of the University, referred to the recent Toronto meeting of the American Association for the Advancement of Science. "Everything available for the special requirements of the Association," he said, "was placed at the disposal of the Sections; and we are gratified by the assurance that, at the close of a highly successful meeting, our visitors carried away with them pleasant memories of their reception here." The meeting of the representatives of science in the buildings of the Toronto University was in some respects, as the President pointed out, peculiarly opportune. "The long-felt need of adequately furnished and equipped laboratories and lecture-rooms for our scientific staff was anew brought into prominence by the restoration to the University of its Medical Faculty; and we now enter on the work of another year provided with buildings admirably adapted for biological and physiological study and research. Plans, moreover, have been approved of, which, when carried out to their full extent, will furnish equally satisfactory accommodation for the departments of botany, chemistry, geology, and palæontology, along with laboratories, work-rooms, museum, and other requisites for efficient instruction in the various branches of science."

THE thirty-fourth general meeting of the Society for Psychical Research was held on Friday afternoon, October 25, at the Westminster Town Hall. The President (Prof. Sidgwick) gave an account of the International Congress of Experimental Psychology held in Paris last August. The Congress had adopted the scheme of a census of hallucinations, already set on foot by the Society for Psychical Research in England, France, and the United States, and it was hoped that the collection of statistics might gradually be extended to other European countries. Much matter valuable to psychologists was

thus being collected; and he trusted that fresh light would be thrown on the subject of coincidental or veridical hallucinations, which specially interested their Society. He would be glad to supply information in reply to letters addressed to him at Hill Side, Cambridge. A paper on recent telepathic experiences was also read.

WE learn from *Humboldt* that the project of a lacustrine biological station on Lake Plön, in East Holstein, is likely to be soon carried out, thanks to the energy of Dr. Otto Zacharias, and the liberality of the Bohemian Baron Bela Dertcheni. This station is to afford Prof. Anton Fritsch, of Prague, and his assistants, constant opportunities of research on fresh-water fauna. The scheme finds a good deal of favour in Berlin, and it is hoped that the researches at the station may prove of considerable benefit to fisheries.

WE send to America some return for the Colorado beetle and the Canadian water-weed. The "weed-law" of the State of Wisconsin requires from farmers, under penalties, the destruction of the following weeds:—*Cnicus arvensis*, *Arctium Lappa*, *Chrysanthemum Leucanthemum*, *Sonchus arvensis*, *Xanthium strumarium*, *Linaria vulgaris*, and *Rumex crispus*. Only one of these is a native of the United States; all the rest being naturalized importations from Europe, and common wild plants in this country.

PROF. RIGHI showed, last year, that ultra-violet radiations reduce to the same potential two conductors, a plate and a piece of netting, applied to each other, the rays being thrown on the netting-side. He now points out (*Riv. Sci. Ind.*, July-August) that this suggests a very simple and convenient way of measuring differences of potential of contact. One notes the deflection of an electrometer connected with the plate (the netting being permanently connected with earth); then, having connected the electrometer for an instant with earth, makes the radiations act a sufficient time. He used a zinc electric lamp, and the metals examined were placed in some cases in a bell jar, to which some gas or vapour was admitted. From measurements of different plates with the same metallic net (copper, zinc, or platinum), the differences of potential of pairs of metals could be deduced. Prof. Righi found the differences sensibly the same in dry and moist air and in carbonic anhydride; but with hydrogen, very different values (from those in air) appeared, where one of the metals examined was platinum, palladium, nickel, or iron (doubtless owing to absorption). In ammonia all the metals, examined with zinc net, seemed to have become less oxidizable; and in coal gas, carbon and platinum behaved like more oxidizable metals. A memoir on the subject will shortly appear.

IN an interesting paper on the management of aquaria, printed in the Bulletin of the United States Fish Commission, Mr. W. P. Seal points out that, in the feeding of the fish, care must be taken to introduce no more food than they can eat in a short time, as what is not eaten will soon decompose and make the water cloudy, and generate noxious gases as well. If due care is observed in regard to quantity, it does not matter how often fish are fed, except that if fed abundantly they will grow rapidly, which is not generally desired. Fish may be fed every day, or but two or three times a week, with equally good results apparently. They will always find a small amount of food in the aquarium in the vegetation. Where they are not fed sufficiently, they are apt to strip the plants of their leaves. In a natural condition fish are feeding continually and grow very rapidly.

ON November 2 a slight shock of earthquake was felt in St. Louis, U.S.A., and the vicinity.

THE following summary of the phases of Vesuvius during the past year has been supplied by Prof. Palmieri, of the Vesuvian

Observatory of the University of Naples, to the British Consul there, and is appended by the latter to his last Report. Mount Vesuvius, during the past year, has continued its moderately eruptive activity, which began in the month of December 1875. There were various emissions of small lava streams, which did not reach further than the base of the cone. An additional cone was gradually formed, caused by the activity of the motive power of the crater which, towards the end of the year, had reached a height of 100 metres (equal to 328 feet) above its original level. On various occasions the detonations and the red-hot projectiles thrown up with the large quantities of smoke indicated greater eruptive power. During the whole year no ashes were thrown up, and consequently the crops in the surrounding country were not destroyed. The sublimations on the smoke issues were relatively scarce, and did not present any product that called for attention. The seismographic instruments at the Observatory did not show an activity proportionate to that of the volcano. All the lava streams that issued during the year flowed towards the eastern slopes of the mountain.

THE Meteorological Council have published Part I. of the Quarterly Weather Report for 1880. The work is (as before) divided into three sections: (1) a general summary of the chief features of the weather for the quarter; (2) tables showing the movements and peculiarities of the principal cyclonic and anti-cyclonic systems; and (3) remarks on the distribution of the various elements for each month, illustrated by charts. An appendix contains tables and diagrams illustrating the diurnal range of the barometer in Great Britain and Ireland during the years 1876-80, by F. C. Bayard. The data used are the hourly observations at seven Observatories in connection with the Meteorological Office, and at Greenwich and Liverpool Observatories. The paper shows that, even in these high latitudes, the daily range is well marked during all months, notwithstanding the interference caused by non-periodic changes. Important seasonal differences are shown, the morning maximum being distinctly higher than the evening maximum in winter, while in summer the evening maximum is the higher of the two. The values exhibit the influence of locality on the amplitude and epoch of the diurnal inequalities, and furnish material for more minute inquiry.

IT is interesting to read of a part of the world where the buffalo is not dying out, but increasing in numbers. A journal of Perth, in Western Australia, says that few Australians are aware that certain parts of Northern Australia have vast herds of the wild buffalo (*Bos bubalus*) careering over its plains and wallowing in its shady pools. The *Sydney Mail* states that the animals are massive and heavy, with splendid horns, and afford sport of a sufficiently dangerous nature to possess charms for the most daring hunter, a wounded buffalo being one of the most dangerous animals known, his great weight, prominent horns, and splendid courage, making him as well respected as sought after. The first buffaloes were landed at Port Essington, North Australia, about the year 1829.

THE *Naturalist's Gazette* has issued an excellent series of what it calls "label lists." On one sheet there is a list of British birds' eggs; on another, a list of dragon-flies; on another, a list of British butterflies; and so on. The names are printed in suitable type on gummed paper, and collectors, in labelling their specimens, will find the lists of considerable service.

THE next volume of Messrs. Ward, Lock, and Co.'s "Minerva Library of Famous Books" will be "Travels on the Amazon and Rio Negro," by Dr. Alfred Russel Wallace.

F. A. BROCKHAUS, 16 Querstrasse, Leipzig, has issued a catalogue, in four parts, containing lists of works relating to various branches of botany.

THE *Colonies and India* states that a discovery has recently been made on a Fiji plantation, which will probably prove extremely valuable in all tropical countries where the cultivation of bananas is regarded as a settled industry. The banana disease had for some time been causing much havoc on a plantation on Vanua Levu, and it appears that the discovery of an antidote was due to an accidental occurrence. On a flat near the seashore there was a patch of bananas much diseased, and some time ago the sea swept into it and remained on it for about an hour. All the plants were killed as far as the standing stems were concerned, but vigorous young shoots came up freely from the roots, and were not only quite free from disease, but soon began to bear much larger bunches of fruit than the parent plants ever did. Upon noting this effect the planters determined to try the experiment upon a number of badly diseased plants which the sea had not reached. They cut down the diseased plants, and, having stirred the ground about them, poured from one to four buckets of sea-water over each. The result was that, while the parent stems withered, vigorous young shoots came freely away, without a sign of disease.

A SERIES of successful experiments upon the simultaneous production of pure crystals of sodium carbonate and chlorine gas from common salt are described by Dr. Hempel in the current number of the *Berichte*. The experiments simply consisted in passing a current of carbon dioxide gas through a solution of salt contained in a special form of electrolytic cell, through which an electric current from a few Bunsen's cells or a small dynamo was circulated. The kathode found most convenient consisted of a plate of iron or carbon perforated with numerous holes about 4 millimetres in diameter, bored obliquely, so that bubbles of gas could readily escape upwards. For anode a similar plate of thin perforated carbon was employed. Both electrodes were circular in shape, and between them was placed a diaphragm of thick asbestos paper, which was directly squeezed between the two plates. This arrangement was found to possess the double advantage of bringing the two electrodes within 1 millimetre of each other, and so greatly diminishing the internal resistance, and of affording such excellent support to the asbestos diaphragm that any rupture of the latter was entirely prevented. The electrodes and their enclosed diaphragm were supported in a circular glass cell in such a manner that they divided the cell into two distinct chambers. To the glass wall of the cell on the positive or anode side was fitted a wide side tube, through which the salt was supplied as often as necessary in solid pieces, a little water being also from time to time added to replace that taken up in the crystallization of the sodium carbonate. A delivery tube was also attached to the upper portion of the anode chamber in order to conduct away the liberated chlorine gas. The negative or kathode chamber was supplied at its upper end with an opening serving on the one hand to introduce the carbon dioxide delivery tube, and on the other to extract the crystals of sodium carbonate. The apparatus was thus found to work continuously for weeks together, the asbestos diaphragm withstanding the pressure very satisfactorily. The separation of the soda crystals is readily explained by the well-known fact of the difficult solubility of sodium carbonate in solutions of sodium chloride; as fast as the electric current decomposes the sodium chloride into chlorine and sodium, the carbon dioxide converts the sodium hydrate formed by the reaction of the sodium upon water into the normal carbonate, which, in presence of the constantly replenished common salt, at once separates in the usual monoclinic form of  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ . The total resistance of the cell is only about five and a half volts, which may be still further reduced by constructing both electrodes of carbon. Using a small dynamo-electric machine, 64.5 grams of chlorine and 259.8 grams of  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$  per horse-power of 630 volt-amperes were pro-

duced per hour, so that the experiments, in addition to their interest from a purely chemical point of view, may turn out to bear fruit technically. The soda produced is stated to be chemically pure, and the chlorine to contain but a very small admixture with other gases.

THE additions to the Zoological Society's Gardens during the past week include a Patas Monkey (*Cercopithecus patas* ♂) from West Africa, presented by the Rev. James Vernal; a Cheetah (*Cynelurus jubatus* ♂) from South Africa, presented by Captain M. P. Webster, s.s. *Roslin Castle*; a Ring-tailed Coati (*Nasua rufa* ♀) from South America, presented by Mr. J. A. Martin; two Short-toed Larks (*Calandrella brachydactyla*) from Devonshire, presented by Commander W. N. Latham, R.N., F.Z.S.; a Sharp-nosed Crocodile (*Crocodilus acutus*) from Jamaica, presented by the Jamaica Institute; two Tuatera Lizards (*Sphenodon punctatus*) from New Zealand, presented by Rear-Admiral Henry Fairfax, R.N., C.B., F.Z.S.; a Smooth-headed Capuchin (*Cebus monachus* ♂) from Brazil, deposited; a Collared Peccary (*Dicotyles tajaçu* ♀), four Rosy-billed Ducks (*Metopiana peposaca* ♂ ♂ ♀ ♀) from South America; two Grey Squirrels (*Sciurus cinereus*) from North America; four — Finches (*Munia nana*) from Madagascar, purchased.

#### OUR ASTRONOMICAL COLUMN.

STELLAR PARALLAX BY MEANS OF PHOTOGRAPHY.—Prof. Pritchard has sent us his eminently successful "Researches in Stellar Parallax" by the aid of photography, from observations made at the Oxford University Observatory. The advantage in point of convenience and rapidity in the multiplication of observations which this method possesses over all others is incalculable, and it is interesting to note that in the case of 61 Cygni the parallax obtained was  $0''.4294 \pm 0''.0162$ , and that Bessel's probable error is practically identical with this here stated. Hence, as far as the present results are concerned, photographic and heliometric measures of parallax may be regarded as possessing an equality of accuracy.

The following list contains the stars whose parallax has been determined by this novel method, and some of the results obtained:—

61, Cygni	...	...	...	+ 0.429	± 0.016
61 <sub>2</sub> "	...	...	...	+ 0.432	± 0.019
μ Cassiopeie	...	...	...	+ 0.021	± 0.023
Polaris	...	...	...	+ 0.052	± 0.011
α Cassiopeie	...	...	...	+ 0.035	± 0.024
β "	...	...	...	+ 0.157	± 0.036
γ "	...	...	...	- 0.032	± 0.026
α Cephei	...	...	...	+ 0.073	± 0.031

The almost identical parallax of the two components of 61 Cygni is worthy of note. The average of eight determinations gives a value  $0''.437$ , which is a close approximation to Dr. Belopolsky's value of  $0''.50$  as the absolute parallax of 61 Cygni.

Bessel determined a small negative parallax for μ Cassiopeie, but Dr. Struve assigned it a value +  $0''.342$ . The very small positive parallax given by Prof. Pritchard may be explanatory of Bessel's negative determination.

The small negative parallax found for γ Cassiopeie would indicate that it and the comparison stars are in the same group, although its bright line spectrum points to a constitution different from that of other stars in this constellation.

Even a cursory examination of the summary of results renders it evident that no relation exists between the lustre and parallax of stars, and indeed, since we probably view bodies which are still in various stages of condensation, we should hardly expect to find any such relation.

MEASUREMENTS OF DOUBLE STARS.—*Astronomische Nachrichten*, Nos. 2929-30, contain a series of double star observations made with the 36-inch refractor of the Lick Observatory by Mr. S. W. Burnham. The discovery is claimed of two very faint stars in the trapezium of Orion, and an excessively faint double has also been detected by Mr. E. E. Barnard just outside and preceding the trapezium. The observers believe that, in spite of the numerous alleged discoveries of faint stars in this



region, it is impossible to see such as these now found with an aperture much less than that of the Lick telescope. A list is therefore given of the principal communications to astronomical periodicals relating to the alleged discovery of faint stars in the trapezium of Orion.

**BARNARD'S COMET, 1888-89.**—*Comptes rendus*, No. 17, October 21, 1889, contains some observations made by MM. Rayet and Courty of the motion of Barnard's comet, the positions of the comparison stars being also given. The series of observations extend from September 11, 1888, to September 27, 1889.

**BIOGRAPHICAL NOTE ON J. C. HOUZEAU.**—M. A. Lancaster, the collaborator with Houzeau of the most comprehensive bibliography extant, has proved himself, in this note, to be the most capable of writing his deceased friend's biography. Houzeau's scientific and literary labours cover an extensive field: astronomy and geodesy, mathematics and meteorology, geology and geography, are all represented in his works; and when but a young man, he directed the triangulation of his country. In politics Houzeau was an enthusiast, and whilst in America, about 1861-69, he gave a considerable amount of attention to the subject of the emancipation of the slaves, and wrote numerous and important articles upon it. In 1875, Houzeau completed a series of astronomical and meteorological observations made at Jamaica, and in the following year was appointed Director of the Brussels Observatory. His crowning work—the "Vade Mecum of Astronomy," was finished in 1882. It represented the work of a lifetime, and as a guide to astronomers is invaluable. Such a compilation, however, calls for continual additions, and a general bibliography was published in 1887, with the assistance of M. A. Lancaster. This was Houzeau's last work, but before his death, on July 12, 1888, he earnestly expressed the wish that it should be carried on by his collaborator. Houzeau's life was full of vicissitudes, and his biography is most interesting.

**THE KARLSRUHE OBSERVATORY.**—The third volume of the Publications of the Grand-Ducal Observatory of Karlsruhe has recently been published by Dr. W. Valentiner, the Director. The bulk of the volume is by Dr. E. von Rebeur-Paschwitz, and consists, first, of a series of measures with the 6-inch refractor of the two star-clusters M. 35 and M. 25; secondly, of a discussion of the orbit of Comet Wells, 1882 I., and the derivation of definitive elements; and lastly, of auxiliary tables for the computation of parallax for 169 different observatories.

Dr. Boy Mattheissen adds a short paper on the orbit of Comet Denning, 1881 V.

The volume contains three plates, the first two being maps of the star-clusters under observation, whilst the third gives photographs of the same two clusters as taken by Dr. E. von Gothard at Herény.

#### OBJECTS FOR THE SPECTROSCOPE.

Sidereal Time at Greenwich, at 10 p.m. November 7 = 1h. 9m. 9s.

Name.	Mag.	Colour.	R.A. 1890°.	Decl. 1890°.
(1) Nebula in Andromeda	—	Greenish-white.	h. m. s.	° ' "
(2) γ Cassiopeiæ ... ..	2	Bluish-white.	0 35 4	+40 30' 14
(3) 47 Piscium ... ..	5	Bluish-white.	0 50 1	+60 7
(4) ε Ceti ... ..	5	Yellowish-red.	0 42 58	+65 59' 2
(5) γ Pegasi ... ..	3	Yellowish-white.	0 13 48	— 9 26
(6) D.M. + 34° 55' ... ..	8	White.	0 7 34	+14 34
(7) T Herculis ... ..	Var.	Deep red.	0 21 42	+34 54
		Reddish.	18 4 50	+31 0

#### Remarks.

(1) Dr. Huggins notes that the spectrum ends abruptly in the orange. Maxima of brightness have since been recorded by myself at, approximately, 468-474, 517, and 546, and the latter two have also been confirmed by Mr. Taylor. Further confirmation is required. For comparison, a Bunsen or spirit-lamp flame will be found convenient for the first two, and the brightest fluting seen when lead chloride is introduced into the flame for the third. Mr. Lockyer suggests that since the central condensation is probably at a higher temperature than the surrounding portions of the nebula, different parts of the nebula should show differences in their spectra. Observing with Mr. Lockyer's 30-inch reflector at Westgate-on-Sea, on October 20, I suspected

some change in the spectrum away from the nucleus, but was unable to complete the observation on account of clouds, and have not since had an opportunity of repeating it.

(2) The bright lines most constantly seen in the spectrum of this star are C, F, and D<sub>3</sub>, but their appearance is somewhat irregular. Continuous observations, with special reference to the relative intensities of the lines, are suggested. The lines are well seen in a 10-inch equatorial with a Maclean spectroscopic eye-piece. Bright flutings of carbon have also been suspected, and comparisons should be made with the Bunsen or spirit-lamp to confirm these. The continuous spectrum should also be carefully examined for maxima. b, D, and other absorption-lines, have also been recorded.

(3) This is a star which gives a spectrum of dark flutings fading away towards the red. Duncér records bands 2 to 9, and describes the spectrum as superb. Band 3, near D, is of extraordinary width. The spectra of this type have been explained as mixed metallic fluting absorption and carbon fluting radiation. The carbon flutings probably present are 517 and 468-474, which again may be determined by comparison with the spirit-lamp, 517 being the brightest green fluting.

Duncér's notation and mean wave-lengths of the dark bands are as follows:—(1) 648-666, (2) 616-2-629-8, (3) 586 7-596-8, (4) 559-8-564-9, (5) 545-2-551-5, (6) 524-3-528-1, (7) 516-8-522-2, (8) 495-9-503-0, (9) 476-0-483-0, (10) 460-7-473. The bright spaces between 7 and 8, and 9 and 10 are probably due to carbon.

(4) This is a star of Class II.a, which is now divided into two groups, one having spectra of the type of α Tauri (Group III.), and the other of the sun (Group V.). The lines should be carefully observed, and differences from the solar spectrum, if any, noted, so that the star can be classed in one group or the other. The principal criteria so far determined for Group III. are strong lines at 499 and 540, 568 and 579. The line at 540 forms with E (5268), and the iron line at 5327 (both solar lines), an equi-distant trio. The difference between the two groups may perhaps best be observed by a comparison of Aldebaran and Capella.

(5) The spectrum of this star is Class I.a (Group IV.). The relative intensities of the hydrogen and metallic lines should be noted, in order that the star may be arranged with others in order of temperature.

(6) Duncér gives the spectrum of this star as Class III.b (Group VI.), in which the main features are three dark carbon flutings fading away towards the blue. Other absorptions, if any, should be carefully observed, and their relative intensities recorded.

(7) This is a variable star, which reached its maximum on November 6. The magnitude at maximum is given by Gore as 6-9-8-3, and the period as 165-1 days. The spectrum has not yet, so far as I know, been recorded.

A. FOWLER.

#### GEOGRAPHICAL NOTES.

THE telegrams in the papers of Monday and Tuesday from Mr. Stanley are of the most suggestive and interesting character. For one thing, Emin, Casati, and others who have been holding out, are safe, though the brave Pasha has evidently been deserted by most of his men. That Mr. Stanley's expedition was needed the result has proved. He reached the Albert Nyanza for the third time, not a moment too soon to rescue the retreating party. We need not dwell on the sacrifices that have been entailed; they might to some extent have been avoided, but personally Mr. Stanley is not to blame. The geographical results of the expedition, as shadowed in the too brief telegram in Tuesday's papers, are evidently of the highest interest. There is now no doubt that there is a southern Albert Lake, Muta Nzige, which Mr. Stanley has named Lake Albert Edward. From the time when he himself discovered what he called Beatrice Gulf until the present, no one had seen this lake. At first it was thought to be a part of the northern lake, Albert Nyanza, but that idea had to be given up. Now it is clear that it is connected with that lake by the River Sempliki. The southern lake is 900 feet higher than the northern, and so is about 3200 feet above sea-level, and 450 feet above Lake Tanganyika, with which it is unlikely to have any connection. Mr. Stanley skirted the snowy mountain range referred to in his letters of six months ago, and found that they send down fifty streams to feed the

<sup>1</sup> Roy. Soc. Proc., vol. xlv. pp. 380-392.



Sempliki. Awamba, Usongora, Toro, Ahaiyama, Unyampaka, and Anhozi, are all districts around the west, north, and east shores of the Lake Albert Edward, three sides of which Mr. Stanley says he has traversed—probably the east, west, and north sides, though it is possible he may have gone round the south side. It is probable that the lake as laid down on our maps is much too large, and that it is comparatively small. Mr. Stanley found it to be 15 miles wide at Beatrice Gulf. From the lake he struck south-east to Karagwe and Uzinze, on the south-west and south of Victoria Nyanza, and no doubt found at Mslala the stores which have been accumulating for many months. Thus it will be seen Mr. Stanley has solved one of the few remaining problems of African geography. He has found the south-west source of the Nile, and established the true relations which exist among the great lakes of Central Africa. He has filled up an important blank in our maps, and collected observations which will enable us to understand the physical geography of one of the most interesting regions on the continent. Probably he will be able to tell us what has become of the Alexandra Lake of his former expedition. It may be as well to state that the telegram of Monday was in effect the first part of that of Tuesday, and therefore Emin's safety was not again referred to in the latter.

The Zanzibar Correspondent of the *Times* telegraphed on November 5 that authentic news had reached Lamu that Dr. Peters and the whole of his party had been massacred, except one European and one Somali, wounded, who are at Ngao. Some say they were killed by Masais, and some by Somalis.

From the Journal of the Anthropological Society in Vienna, we take the following conclusions of Dr. B. Hagen, respecting the Malay peoples:—Their great predilection for the sea, which makes them pray to Allah that they may die on sea, seems to render the Malay race adapted for the Polynesian and Further Indian Archipelago. The centre from which they migrated is to be sought in the highlands of West Sumatra, particularly in the old kingdom of Menang-Kabau. Thence the peoples extended slowly eastwards; at first probably the races now to be found only in the interior of the great islands (the Battas in Sumatra, the Sundanese in Java, the Dayaks in Borneo, the Alfurus in Celebes, &c.). These "aborigines" of the islands crushed out a population already in possession, as remains of which the Negritos may be taken. The Malays in the narrower sense occupying Sumatra, Malacca, and North Borneo, are to be regarded as the last emigration from the centre referred to, occurring from the twelfth to the fifteenth century A.D. With the Indians and Chinese, who have been long in intercourse with the archipelago, arose mixtures and crosses, in less measure also with the Arabs. One must not therefore expect the pure racial type, especially in the coast population. The crania of the anthropological collections are too imperfectly determined in respect of their *locale* to be of any service for a judgment of the Malay peoples. Of more value are the measurements of the living begun by Dr. Weisbach and executed by Dr. Hagen in 400 cases. The latter's conclusions are:—(1) The peoples in the interior of Sumatra—the Battas, the Allas, and the Malays of Menang-Kabau—compose a closely allied group always in direct contrast with the hither-Indian peoples, and yet showing just as little community with the Chinese. We must therefore take them for the pure original type, characterizable as follows:—Small, compact, vigorous figure of less than 1600 mm. average size; long arms; very short legs; very long and broad mesocephalous skull of very great compass, with high forehead; a prognathous face 10 per cent. broader than long, with large mouth, and uncommonly short, flat, and broad nose with large round nostrils opening mostly frontwise, and with broad nasal root. (2) The Malays of the east coast of Sumatra and those of the coasts of Malacca indicate a much greater affinity to the Indians than to their tribal peoples of Menang-Kabau. They are plainly therefore thoroughly mixed with Indian blood. (3) The Javanese peoples stand much nearer to the original type of the Sumatrans than to the Malays just mentioned. They show therefore less mixture with Indian, but on the other hand more mixture with Chinese, blood, and the Javanese more so than the Sundanese.

THE second number of this year's "Information respecting Kaiser Wilhelm's land and the Bismarck Archipelago," issued by the German New Guinea Company, contains a description of the north coast of New Guinea, from Cape

Cretin to the Legoarant Islands, by the former Governor, Vice-Admiral Freiherr von Schleinitz, with a map designed by him. According to this account, Kaiser Wilhelm's land is subject to the south-east trade wind. This is, however, occasionally relieved by the opposite wind, when, viz., the sun in southing imparts to the Australian continent a temperature higher than that of New Guinea. The temperature, averaging  $26^{\circ}$  to  $27^{\circ}$  C., is not so high as might be inferred from the equatorial situation of the land, a fact due in part to the prevalence of the trade wind, which also brings with it a cooling sea-current to the coast, and in part to the considerable elevation of most of the island. The north-west, blowing especially from January to April, comes on the whole with greater force than the south-east. Calms often occur from March to May and from October to December. Precipitation is on the whole copious, but there are many differences according to the local variations in the configuration of the land. The navigation of the coast offers no particular dangers and difficulties, either for steamers or sailing-vessels. Serious storms are extremely rare, nor are there any reefs in the channel proper. Sea currents do not strike direct on the coast, and they are not generally very strong. The tides are inconsiderable, the spring floods keeping under 1 metre.

SOME interesting remains have been found in Hamburg on the site of the new Rathaus. At a depth of 0 to 0.7 metre the ground was covered to a height of 10 to 15 centimetres with dams of thin willow twigs (*Salix fragilis*), in many places two, sometimes even three, layers above one another, and separated from one another by equally thick earth layers. The building rests on clay, i.e. submerged ground, which contained heaps of freshwater shells, e.g. *Valvata piscinalis*, *Bythinia tentaculata*, &c., as also *Cardium edule*, *Tellina baltica*, *Macra solida*, &c. When therefore the dam was made, the water must have been strongly brackish. The interest in this discovery was heightened when there was found, under St. Anne's Bridge, at a depth of 0.5 metre, a regularly paved street of small boulders, such as were still used for stone pavement in all North German towns in the last century. The stone dam was about 5 metres broad, and encased on both sides by thick wooden planks, in order, in the swampy ground, to prevent the slipping out of the stones sideways. The ascertained changes in the level of the North Sea give no positive clue to the age of the Hamburg finds.

#### THE INSTITUTION OF ELECTRICAL ENGINEERS.

ON Monday evening the first annual dinner of the Institution of Electrical Engineers took place at the Criterion Restaurant, Sir William Thomson, the President, occupying the chair. Many different branches of science were represented on the occasion, and some of the after-dinner speeches rose to a high level of excellence.

Due honour having been done to the usual loyal toasts, and Major Webber and Captain Wharton having responded for the Army and Navy, the Chairman proposed "Her Majesty's Ministers." Lord Salisbury said, in response:—

Sir William Thomson and Gentlemen,—I have to thank you on behalf of my colleagues in the Government and myself for the exceedingly kind reception you have given to the kind words in which Sir William Thomson has proposed this toast. I do not feel that I can accept the guise in which he put my name forward. On the contrary, though recognizing, as every individual must do, and as I have especial reason to do, the enormous benefits which electrical science confers upon mankind, I feel that I have reason rather to apologize for my appearance in this assembly. When I look round on so many learned and distinguished men, I feel rather in the position of a profane person who has got inside the Eleusinian mysteries. But I have an excuse. The gallant gentlemen who replied for the Army and Navy were able to show many particulars in which their special professional vocation was sustained and pushed forward by the discoveries of electrical science. But I will venture to say that there is no department under the Government so profoundly indebted to the discoveries of those who have made this science as the Foreign Office, with which I have the honour to be connected. I may say that we positively exist by virtue of the electric telegraph. The whole

work of all the Chancelleries in Europe is now practically conducted by the light of that great science, which is not so old as the century in which we live. And there is a strange feeling that you have in communicating constantly and frequently day by day with men whose inmost thoughts you know by the telegraph, but whose faces you have never seen. It is something more than a mere departmental effect which these great discoveries have had upon the government of the world. I have often thought that if history were more philosophically written, instead of being divided according to the domination of particular dynasties or the supremacy of particular races, it would be cut off into the compartments indicated by the influence of particular discoveries upon the destinies of mankind. Speaking only of these modern times, you would have the epoch marked by the discovery of gunpowder, the epoch marked by the discovery of the printing-press, and you would have the epoch marked by the discovery of the steam-engine. And those discoveries have had an influence infinitely more powerful, not only upon the large collective destinies, but upon the daily life and experience of multitudes of human beings, than even the careers of the greatest conquerors or the devices of the greatest statesmen. In that list which our ignorance of ancient history in its essential character forbids us to make as long as no doubt it might be made, the last competitor for notice and not the least would be the science of electricity. I think the historian of the future when he looks back will recognize that there has been a larger influence upon the destinies of mankind exercised by this strange and fascinating discovery than even in the discovery of the steam-engine itself, because it is a discovery which operates so immediately upon the moral and intellectual nature and action of mankind. The electric telegraph has achieved this great and paradoxical result, that it has, as it were, assembled all mankind upon one great plane where they can see everything that is done, and hear everything that is said, and judge of every policy that is pursued at the very moment when those events take place; and you have by the action of the electric telegraph, combined together almost at one moment, and acting at one moment upon the agencies which govern mankind, the influences of the whole intelligent world with respect to everything that is passing at that time on the face of the globe. It is a phenomenon to which nothing in the history of our planet up to this time presents anything which is equal or similar, and it is an effect and operation of which the intensity and power increases year by year. When you ask what is the effect of the electric telegraph upon the condition of mankind, I would ask you to think of what is the most conspicuous feature in the politics of our time, the one which occupies the thoughts of every statesman, and which places the whole future of the whole civilized world in a condition of doubt and question. It is the existence of those gigantic armies held in leash by the various Governments of the world, whose tremendous power may be a guarantee for the happiness of mankind and the maintenance of civilization, but who, on the other hand, hold in their hands powers of destruction which are almost equal to the task of levelling civilization to the ground. What gives these armies their power? What enables them to exist? By what power is it that one single will can control these vast millions of men and direct their destructive energies at one moment on one point? What is the condition of simultaneous direction and action which alone gives to these vast armies this tremendous power? It is nothing less than the electric telegraph. And it is from that small discovery, worked out by a few distinguished men in their laboratories upon experiments of an apparently trivial character, on matter and instruments not, in the first instance, of a very recondite description—it is on that discovery that the huge belligerent power of modern States, which marks off our epoch of history from all that have gone before, must be held, by anyone who investigates into the causes of things, absolutely to depend. I would venture to hope that this is not all, in its great effect upon the history and government of our race, that electricity may achieve. Whether it so far is good or evil in the main, it must be for the future to determine. We only know that the effect, whatever it is, will be gigantic. But in the latter half of the short life of this young science another aspect of it has been developed—an aspect which I cannot help hoping may be connected with great benefits to the vast community of industrious and labouring men—I mean that facility for the distribution of power of which electricity has given such a splendid instance. The event of the last century was the discovery of the steam-engine. But the steam-engine

was such that the forces which it produced could only act in its own immediate neighbourhood, and therefore those who were to utilize its forces and translate them into practical work were compelled to gather round the steam-engine in vast factories, in great manufacturing towns, and in great establishments where men were collected together in unnatural, and often unwholesome, aggregation. Now an agent has been discovered, by which the forces of the steam-engine, stiff, confined to its own centre, can be carried along, far away from its original sources, to distances which are already great, and which science promises to make more considerable still. I do not despair of the result that this distribution of forces may scatter those aggregations of humanity, which I think it is not one of the highest merits of the discovery of the steam-engine to have produced. If it ever does happen that in the house of the artisan you can turn on power as now you can turn on gas—and there is nothing in the essence of the problem, nothing in the facts of the science, as we know them, that should prevent such a consummation from taking place—if ever that distribution of power should be so organized, you will then see men and women able to pursue in their own homes many of the industries which now require the aggregation at the factory. You may, above all, see women and children pursue these industries without that disruption of families which is one of the most unhappy results of the present requirements of industry. And if ever that result should come from the discoveries of Oersted and Faraday, you may say that they have done more than merely to add to the physical forces of mankind. They will have done much to sustain that unity, that integrity of the family, upon which rest the moral hopes of our race and the strength of the community to which we belong. These are some of the thoughts which electricity suggests to one of my trade. Pardon me if I have wandered into what may seem to be speculative and unfamiliar fields. But, after all, the point of view from which we must admire the splendid additions to our knowledge which the scientific men of the world, and especially of England, during this century have made, is, that they have enabled mankind to be more happy, to be more contented, and therefore to be more moral.

Sir Frederick Abel proposed, and Sir George Gabriel Stokes responded for, "The Learned Societies"; and Sir John Coode responded for the toast of "The Professional Societies," which was proposed by Mr. Latimer Clark. The toast of "The Institution of Electrical Engineers" was then proposed by Lord Salisbury. In the course of his response, Sir William Thomson said:—

One very remarkable piece of work they should think of especially this year, and during the last few weeks, when they deplored the loss of one of the greatest workers in electrical science and its practical application that the world had ever seen—Joule. The great scientific discoveries of Faraday, which were prepared almost deliberately for the purpose of allowing others to turn them to account for the good of man, had been going on for about fifteen years, when a young man took up the subject with a profound and penetrating genius most rare in any branch of human study, and perceived relations with mechanical power which had never been suspected before. Joule saw the relations between electricity and force, and his very first determination of the mechanical equivalent was an electrical measurement. His communication to the British Association, when it met in Cork in the year 1841, pointed out for the first time the distinct mechanical relation between electric phenomena and mechanical force. Joule was not a mere visionary who saw and admired something in the air, but he pursued what he saw to the very utmost practical point of work, and he it was who determined the mechanical equivalent of heat. Afterwards he thoroughly confirmed the principle of his first determination of the mechanical equivalent of heat. Both in electricity and mechanical action he laid the foundation of the great development of thermodynamics, which would be looked upon in future generations as the crowning scientific work of the present century. It was not all due to Joule, but he had achieved one of the very greatest monuments of scientific work in the present century. For an Institution of Electrical Engineers it was interesting to think that the error relating to one of the most important electrical elements, the unit of resistance (now called the ohm), as determined electrically in the first place by a Committee of the British Association, and by purely electrical method, was first discovered by Joule's mechanical measurement. It was Joule's mechanical measurement which first corrected the British Association unit, and gave the true ohm.

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## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The following examiners have been appointed: Natural Sciences Tripos: Physics, Prof. Carey Foster and W. N. Shaw; Chemistry, Prof. W. A. Tilden and Prof. Living; Mineralogy, Prof. Lewis and L. Fletcher; Geology, Prof. Green and W. W. Watts; Botany, F. Darwin and D. H. Scott; Zoology, Prof. Lankester and S. F. Harmer; Human Anatomy, Drs. Hill and Windle; Physiology, Prof. Stirling and C. S. Sherrington.

First M.B. and Special B.A.: in Elementary Physics, S. L. Hart and H. F. Newall; Elementary Chemistry, F. H. Neville and S. Ruhemann; Elementary Biology, S. F. Harmer and Prof. H. M. Ward; Special B.A. in Geology, Prof. Green and W. W. Watts; in Pharmaceutical Chemistry for Second M.B., M. M. Pattison Muir and H. Robinson.

The following are Moderators (Mathematical Tripos) for the year beginning May 1, 1890:—W. W. R. Ball and A. J. Wallis. Examiners in Part I., W. L. Mollison and E. G. Gallop; in Part II., Prof. Darwin, J. Larmor, and R. Lachlan.

W. B. Hardy, of Gonville and Caius College, has been appointed Junior Demonstrator of Physiology.

L. R. Wilberforce, M.A., of Trinity College, is approved as a Teacher of Physics for M.B. lectures.

There has been a serious discussion of the financial management and prospects of the mechanical workshops at Cambridge. Whatever be the merits of the points in dispute, such division of opinion and feeling is very unfortunate, and much to be deplored in the interests of mechanical science and engineering in the University. It was unfortunate that the University declined to establish an advanced examination or Tripos in engineering subjects; and it is calamitous that the Museums work should not be given to the Department located within their own borders. We trust a cordial understanding may soon be re-established; for this division is very unlike the strong action by which, even when opinions have been divided, scientific teaching has steadily progressed of late years at Cambridge.

The managers of the John Lucas Walker Fund, have made the following grants in aid of original research in pathology:—£14 2s. 3d. to J. G. Adami, Demonstrator of Pathology, for expenses of his investigations on the pathology of the heart; £35 to William Hunter, M.D. Edin., John Lucas Walker Student, to defray expenses incurred in his research on the pathology of the blood; £30 to E. Hanbury Hankin, to defray expenses of his research on the nature of immunity from infectious diseases.

Mr. J. W. Clark has been re-elected President of the Philosophical Society.

ST. JOHN'S COLLEGE.—At the annual election of Fellows, on Nov. 4, the choice of the Council fell upon the following members of the College: John Parker, Seventh Wrangler, 1882, well known as the author of numerous papers, in the *Philosophical Magazine* and elsewhere, on thermodynamics and electricity; Humphry Davy Rolleston, First Class Natural Sciences Tripos (Human Anatomy and Physiology), 1886, who has been University Demonstrator in Pathology, in Human Anatomy, and in Physiology, author of memoirs on endocardiac pressure and on other anatomical, physiological, and pharmacological subjects, now one of the Assistant Demonstrators of Anatomy at St. Bartholomew's Hospital; Alfred William Flux, bracketed Senior Wrangler, 1887, and First Class (Division 1) Mathematical Tripos, Part II., 1888, Marshall Prizeman in Political Economy, 1886, author of papers on physical optics. Mr. Rolleston is the son of the late Prof. Rolleston, of Oxford. The success of students of physical and biological science at this College is striking.

## SOCIETIES AND ACADEMIES.

## PARIS.

Academy of Sciences, October 28.—M. Des Cloizeaux, President, in the chair.—M. Bertrand presented a volume entitled "Lectures on the Mathematical Theory of Electricity, delivered at the College of France."—On some hybrids observed recently in Provence, by M. G. De Saporta. Three are described: (1) between *Pinus halepensis*, Mill., and *P. pinaster*, L.; (2) between *Quercus Mirbeckii* and *Q. pubescens*, Willd.; (3) between *Tilia platyphyllo*, Scop., and *T. argentea*, Desf.; in each case, the pollen of a preponderating species acting on that of a subordinate one, or one accidentally introduced, being

carried by wind or insects, while the agency of man, birds, or wind, disseminated the hybrid seeds.—On the relation of certain magnetic perturbations to earthquakes, by M. Mascart. The former, in the Park of St. Maur, and the latter, at Gallipoli, seem to have occurred simultaneously at 11.35 p.m. on October 25. The suspended copper bar was not in the least deflected, and the magnetic disturbance cannot be attributed to mechanical transmission of the shock.—On certain harmonic linear elements, by M. Raffy.—On a formula connecting vapour-pressure with temperature, by M. N. de Salsff.—On the equilibrium of distribution between chlorine and oxygen, by M. H. Le Chatelier. He shows that the value of all the coefficients may be calculated *a priori*, and supplies the required formulæ.—On some double nitrites of ruthenium and potassium, by MM. A. Joly and M. Vèzes. In contact with alkaline nitrites, the brown sesquichloride of ruthenium is transformed into a red salt. According to the temperature, and according as the nitrite or the red chloride predominate, a deposit is formed either of yellow crystalline powder, sparingly soluble in cold water, or of large, very soluble orange-red crystals. These two substances are double nitrites of potassium and ruthenium. The formulæ obtained do not at all agree with those for similar compounds obtained by Claus.—Fixation of nitrogen by the Leguminosæ, by M. Bréal. Having before found that nodosities full of Bacteria could be easily produced on the roots of a leguminous plant, by pricking with a needle previously inserted in a nodosity, he here shows that such plants, with nodosities, flourish on soil poor in azotized matter; yielding crops rich in nitrogen, and fixing this element in the soil by their roots.—On air in the soil, by M. Th. Schloesing, fils. Ploughed land was found to contain a relatively large amount of oxygen at least to the depth of 50 or 60 cm. The carbonic acid generally increased with the depth; but in two cases the reverse occurred, when high wind (renovating the upper layer) had been followed by hot and calm weather, and more CO<sub>2</sub> was generated in the soil than in the sub-soil. In sloping pastures, most CO<sub>2</sub> was found at the bottom. The mobility of air in the soil should be taken into account.—On sorbite, by MM. Vincent and Delachanal. This substance very frequently occurs in nature; it is found in all fruits of Rosaceæ, and is especially abundant in pears (8 grammes per kilogramme), cherries and prunes (7 grammes). Acted on by hydriodic acid it yields β-hexylene and other products (the same as are thus obtained from mannite). The formation of a hexacetyl derivative from sorbite proves that it is a hexatomic alcohol. The formula of anhydrous sorbite is C<sub>6</sub>H<sub>8</sub>(OH)<sub>6</sub>.—Researches on crystallized digitaline, by M. Arnaud. He regards it as a definite chemical species; and it appears to be the type of a whole series, including tanghinine (one of the active principles of the tanguin).—Experimental researches on the metamorphosis of Anoura, by M. E. Bataillon. He finds acceleration of the rhythm of respiration (65 to 120), and retardation of that of the heart (70 to 45) during metamorphosis. Before appearance of the fore-legs, the two movements were nearly synchronous. At the stage of this appearance, further, the production of carbonic acid was found to have diminished considerably, and the curve rose suddenly when aerial respiration was established.—On the earthquake of July 28, 1889, in the island of Kiushiu, in Japan, by M. J. Wada. This was preceded by exceptional rains during July. The longer axis of the ellipse of land affected was north-east to south-west, and cut in the middle, at right angles, the line joining two volcanoes, 100 kilometres apart.

## BERLIN.

Physiological Society, October 18.—Prof. du Bois-Reymond, President, in the chair.—Prof. Kossel spoke on the application of the microscope in connection with physiological chemistry. It has long been the practice to seek for and identify any minute crystals in tissues which occur either naturally or as the result of treatment with reagents, in order to arrive at a qualitative determination of the localized distribution of certain well-known substances in the organism. To identify a crystal by measurement of its angles is a laborious process, and to determine it by mere comparison of its appearance with drawings of known crystals is insufficient. The optical properties of crystals are extremely well adapted to assist in their identification; this is exemplified in the case of determining the plane of vibration of the ordinary and extraordinary rays when crystals are examined between crossed Nicols. To carry out the determination by this means, the field of view of the microscope is provided with cross-wires,



whose directions are parallel to the principal planes of the two Nicols. The crystal under examination is then placed with one edge under one of the cross-wires; if the field of vision remains dark, then the planes of vibration in the crystal are known to correspond to the chief planes of the two Nicols. If, however, the field of vision becomes bright the crystal must be rotated, by means of a graduated object-carrier until it is again dark. The angle through which the carrier has been rotated is a measure of the angular inclination of the planes of vibration to the edges of the crystal. When convergent polarized light is used, the majority of crystals of organic substances, which are mostly biaxial, exhibit a lemniscate whose poles are at varying distances apart for various crystals. The distance between the poles of the lemniscate may be measured by suitable methods, is extremely characteristic for those crystals of greatest physiological importance, and may be used, in conjunction with the measurement of the planes of vibration, as a very certain means of determining the crystal. The pleochromatism of many crystals is itself in many cases sufficiently characteristic.—Dr. Virchow described the distribution of blood-vessels in the eye of Selachians, and the several types according to which the vessels are developed in the eyes of various classes of animals.—Dr. Benda made a communication to the effect that the coiled glands which are so widely distributed as sweat-glands in the skin when they exhibit an enlarged secretory part, and a more complicated structure, are known as cerumenous and as mammary glands. They are characterized specially by the fact that during secretion there is no destruction of their epithelium. These modifications of the typical coiled glands have been found by Dr. Benda in large numbers and widely spread in the skin of Protopterus.—Dr. Schneider spoke on the distribution and significance of iron in the animal organism. He was able to find iron in greater or less quantity in the cell protoplasm and nucleus of all classes of animals, the liver and spleen being the organs in which its occurrence was most marked. The connective tissues were very rich in iron, and it was found with similar constancy in the cuticular layers and quite constantly in the extreme tips of fishes' teeth. The more he extended his investigations over the most widely differing classes of animals, whether on land, or in fresh-water, or in the sea, and the more widely different were the organs he examined, by so much the more was it seen that iron is universally present in the animal organism. Its importance is pre-eminently physiological.

## AMSTERDAM.

**Royal Academy of Sciences, September 28.**—Prof. van der Staals in the chair.—M. Suringar dealt with the Melocacti of Aruba, stating what he had himself observed concerning the development of those plants from seed and their subsequent growth. He spoke also of the manner in which the Melocacti might be classified according to their natural affinities, and sketched a pedigree of the species.—M. Schoute spoke of tetrahedra, bounded by similar triangles, and described a new species with pairs of opposite edges 1 and  $r^3$ ,  $r$  and  $r$ ,  $r^3$  and  $r^2$ .

## STOCKHOLM.

**Royal Academy of Sciences, October 9.**—Musci Asiæ Borealis (second part): feather mosses, by the late Prof. S. O. Lindberg, of Helsingfors, and Dr. H. W. Arnell.—On the permanent committee for a photographic map of the heavens and its work, by one of its members, Prof. Dunér.—On the Metre Congress in Paris, September 14-28, this year, and on the prototypes of the metre and the kilogramme, by Prof. Thalén.—Emanuel Swedenborg as a mathematician, by Dr. G. Eneström.—On naphtic acids, by Dr. A. G. Ekstrand.—Chemical investigation of some minerals from the neighbourhood of Langesund, by Herr H. Bäckström.—An attempt to determine the velocity of light from observations on variable stars, by Dr. C. Charlier.

## DIARY OF SOCIETIES.

## LONDON.

## THURSDAY, NOVEMBER 7.

**LINNEAN SOCIETY, at 8.**—On a Collection of Dried Plants chiefly from the Southern Shan States, Upper Burma: Colonel H. Collett and W. Botting Hemsley, F.R.S.

**CHEMICAL SOCIETY, at 8.**—The Isolation of a New Hydrate of Sulphuric Acid existing in Solution: S. U. Pickering.—Further Observations on the Magnetic Rotation of Nitric Acid, of Hydrogen Chloride, Bromide and Iodide in Solution: Dr. W. H. Perkin, F.R.S.—On Phosphoryl Trifluoride: T. E. Thorpe, F.R.S., and F. T. Hamblin.—On the Acetylation of Cellulose: C. F. Cross and E. Bevan.—On the Action of Light on Moist Oxygen: A. Richardson.—Anhydrazetophenonebenzyl and the Constitution of Linus lepidus: Drs. Japp, F.R.S., and Klingsman.

## FRIDAY, NOVEMBER 8.

**ROYAL ASTRONOMICAL SOCIETY, at 8.**

## MONDAY, NOVEMBER 11.

**ROYAL GEOGRAPHICAL SOCIETY, at 8.30.**—Cyprus: Lieut.-General Sir Robert Biddulph, G.C.M.G.

## TUESDAY, NOVEMBER 12.

**ANTHROPOLOGICAL INSTITUTE, at 8.30.**—Observations on the Natural Colour of the Skin in certain Oriental Races: Dr. J. Beddoe, F.R.S.—Manners, Customs, Superstitions, and Religions of South African Tribes: Rev. James Macdonald.

**INSTITUTION OF CIVIL ENGINEERS, at 8.**—Inaugural Address of Sir John Coode, K.C.M.G., President, and Presentation of Medals, Premiums, and Prizes awarded during Last Session.

## WEDNESDAY, NOVEMBER 13.

**ROYAL MICROSCOPICAL SOCIETY, at 8.**

## THURSDAY, NOVEMBER 14.

**MATHEMATICAL SOCIETY, at 8.**—Isosceles Hexagrams: R. Tucker.—On Euler's  $\phi$ -Function: H. F. Baker.

## FRIDAY, NOVEMBER 15.

**PHYSICAL SOCIETY, at 5.**—On the Electrification due to the Contact of Gases and Liquids: J. Enright.—On the Effect of Repeated Heating and Cooling on the Electrical Resistance and Temperature Coefficient of Annealed Iron: H. Tomlinson, F.R.S.—Notes on Geometrical Optics, Part II.: Prof. S. P. Thompson.

**INSTITUTION OF CIVIL ENGINEERS, at 7.30.**—The New Harbour and Breakwater at Boulogne-sur-Mer: S. C. Bailey.

## BOOKS, PAMPHLETS, and SERIALS RECEIVED.

A Popular Treatise on the Winds: W. Ferrel (Macmillan).—South African Butterflies: vol. iii., Papilionidae and Hesperidae: R. Trimen and J. H. Bowker (Trübner).—Light, 2nd edition: P. G. Tait (Edinburgh, Black).—The Vertebrate Animals of Leicestershire and Rutland: M. Browne (Birmingham, M. E. C.).—Sitzungsberichte der k. b. Gesellschaft der Wissenschaften Math.-Naturw. Classe, 1889, i. (Prag).—Outlines of a Course of Lectures on Human Physiology: E. A. Parkyn (Allman).—Flower-Land: R. Fisher (Bemrose).—Potential and its Application to the Explanation of Electrical Phenomena: R. Tumlirz, translated by D. Robertson (Rivington).—Index Catalogue of the Library of the Surgeon-General's Office, United States Army, vol. x. (Washington).—The Birds of Berwickshire, vol. i.: G. Muirhead (Edinburgh, Douglas).—Idylls of the Field: F. A. Knight (E. Stock).—Atti della Reale Accademia delle Scienze Fisiche e Matematiche, serie seconda, vol. iii. (Napoli).—Ferneries and Aquaria: G. Eggett (Dean).—Traité Encyclopédique de Photographie, 15 Octr. (Paris).

## CONTENTS.

## PAGE

Twenty Years . . . . .	1
Modern Views of Electricity . . . . .	5
The Calculus of Probabilities. By F. Y. E. . . . .	6
Argentine Ornithology. By R. Bowdler Sharpe . . . .	7
Our Book Shelf:—	
Benedikt and Knecht: "The Chemistry of the Coal-Tar Colours." . . . .	8
Gore: "A Bibliography of Geodesy" . . . . .	9
Letters to the Editor:—	
The Method of Quarter-Squares.—J. W. L. Glaisher, F.R.S. . . . .	9
Darwinism.—Prof. E. Ray Lankester, F.R.S. . . .	9
Record of British Earthquakes.—Charles Davison .	9
Effects of Lightning.—W. G. S. . . . .	10
Electrical Cloud Phenomena.—Prof. W. K. Burton .	10
The Use of the Word Antiparallel. (With Diagrams.)—W. J. James . . . . .	10
Fossil Rhizocarps.—Sir J. Wm. Dawson, F.R.S. .	10
Specific Inductive Capacity.—W. A. Rudge . . . .	10
Who discovered the Teeth in Ornithorhynchus?—Dr. C. Hart Merriam . . . . .	11
On the Hardening and Tempering of Steel. (Illustrated.) By Prof. W. C. Roberts-Austen, F.R.S. .	11
On a New Application of Photography to the Demonstration of Certain Physiological Processes in Plants . . . . .	16
Notes . . . . .	17
Our Astronomical Column:—	
Stellar Parallax by Means of Photography . . . .	19
Measurements of Double Stars . . . . .	19
Barnard's Comet, 1888-89 . . . . .	20
Biographical Note on J. C. Houzeau . . . . .	20
The Karlsruhe Observatory . . . . .	20
Objects for the Spectroscope . . . . .	20
Geographical Notes . . . . .	20
The Institution of Electrical Engineers . . . . .	21
University and Educational Intelligence . . . . .	23
Societies and Academies . . . . .	23
Diary of Societies . . . . .	24
Books, Pamphlets, and Serials Received . . . . .	24



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