

THURSDAY, AUGUST 28, 1879

THE BRITISH ASSOCIATION AT SHEFFIELD

THE Forty-ninth Annual Meeting of the British Association must be reckoned one of decided success. The large number and variety of papers read in the sections, the excellence of presidential and sectional addresses and of evening discourses, the satisfaction afforded by local and general arrangements, and not least by the favourable meteorological conditions prevailing during the week, have all contributed to make the Sheffield gathering one to be remembered with pleasure.

The president, Dr. Allman, had the misfortune at the outset to be suffering from a severe cold, which made the delivery of his admirable address somewhat laboured and painful. But his audience proved sympathetic and even enthusiastic; and the printed copies of his address have been eagerly demanded on all hands. Whether prepared to agree with the dictum that irritability as a property of matter is the one grand characteristic phenomenon of all living things, or not, none will dispute the extreme ability and lucidity of the address.

Surprise has been expressed in some quarters that Prof. Allman should have ventured to found such momentous speculations, even partly, on so unstable a basis as "Bathybius," and in this connection Prof. Huxley's remarks in supporting the vote of thanks to the president are well worth reproducing:—

"It is my business to recollect, on the present occasion, that I have come to praise Cæsar, and not to bury him under any mountain of talk of my own; and I will, therefore, not venture to dwell upon any of those very large topics upon which he has dwelt with so much fairness, with so much judgment, and with so remarkable a knowledge of the existing information respecting them. But I will ask you to allow me to say one word rather on my own account, in order to prevent a misconception which, I think, might arise, and which I should regret if it did arise. I dare say that no one in this room, who has attained middle life, has been so fortunate as to reach that age without being obliged now and then to look back upon some acquaintance, or, it may be, intimate ally of his youth, who has not quite verified the promises of that youth. Nay, let us suppose he has done the very reverse, and has become a very questionable sort of character, and a person whose acquaintance does not seem quite so desirable as it was in those young days; his way and yours have separated; you have not heard much about him; but eminently trustworthy persons have assured you he has done this, that, or the other; and is more or less of a black sheep, in fact. The president, in the early part of his address, alluded to a certain thing—I hardly know whether I ought to call it thing or not—of which he gave you the name Bathybius, and he stated, with perfect justice, that I had brought that thing into notice; at any rate, indeed, I christened it, and I am, in a certain sense, its earliest friend. For some time after that interesting Bathybius was launched into the world, a number of admirable persons took the little thing by the hand, and made very much of it, and, as the president was good enough to tell you, I am glad to be able to repeat and verify all the statements, as a matter of fact, which I had ventured to make about it. And so things went on, and I thought my young friend Bathybius would turn out a credit to me. But I am sorry to say, as time has gone on, he has not altogether verified the promise of his youth. In the first place, as the president told you, he could not

be found when he was wanted; and in the second place, when he was found, all sorts of things were said about him. Indeed, I regret to be obliged to tell you that some persons of severe minds went so far as to say that he was nothing but simply a gelatinous precipitate of slime, which had carried down organic matter. If that is so, I am very sorry for it, for whoever else may have joined in this error, I am undoubtedly primarily responsible for it. But I do not know at this present time of my own knowledge how the matter stands. Nothing would please me more than to investigate the matter afresh in the way it ought to be investigated, but that would require a voyage of some time, and the investigation of this thing in its native haunts is a kind of work for which, for many years past, I have had no opportunity, and which I do not think I am very likely to enjoy again. Therefore my own judgment is in an absolute state of suspension about it. I can only warn you what has been said about this friend of mine, but I cannot say whether what is said is justified or not. But I feel very happy about the matter. There is one thing about us men of science, and that is no one who has the greatest prejudice against science can venture to say that we ever endeavour to conceal each other's mistakes. And, therefore, I rest in the most entire and complete confidence that if this should happen to be a blunder of mine, some day or other it will be carefully exposed by somebody. But pray let me remind you whether all this story about Bathybius be right or wrong makes not the smallest difference to the general argument of the remarkable address put before you to-night. All the statements your president has made are just as true, as profoundly true, as if this little eccentric Bathybius did not exist at all. I congratulate you upon having had the opportunity of listening to an address so profound, so exhaustive in all respects, and so remarkable, and I ask you to join in the vote of thanks which has just been proposed."

A clever metrical skit on the president's address by an eminent geologist caused considerable amusement to those who had the privilege of seeing it.

The first of the evening discourses was by Mr. W. Crookes, F.R.S., upon Radiant Matter, and was illustrated by a unique display of those exquisite experiments on the movements of molecules in high vacua which have recently attracted so much attention. Nothing could exceed the beauty or brilliance of the experiments, which were made on a scale sufficiently large to be visible to an audience of nearly two thousand persons. The final experiment of allowing the air to enter through a microscopic hole into an exhausted radiometer bulb of large dimensions afforded the lecturer the means of making a most telling illustration of the enormous figures which must be employed in calculating the numbers of molecules contained in a small space.

The second discourse, by Prof. Ray Lankester, F.R.S., on Degeneration, was an attempt to establish that the laws of organic evolution may work downwards as well as upwards, reducing a free crustacean to a barnacle, or a vertebrate to an ascidian; a view which may at least claim some antiquity on its side since it is but an expansion of the Koran legend of Moses and the men of the Dead Sea who degenerated into apes.

The Saturday evening lecture by Mr. W. E. Ayrton, upon the Transmission of Power by Electricity, was listened to by a crowded audience, a large proportion of whom were working men, and was illustrated experimentally on a large scale.

In the sections much good work has been done. Section A (Mathematics and Physics) has been remarkable for the absence of great names, yet it has been well attended on the whole. A paper on Etherspheres as a *vera causa* in Natural Philosophy, by Rev. S. Earnshaw, has deservedly attracted attention as giving forth a most ingenious speculation on the mechanics, so to speak, of

the relation between matter and energy. Mr. Gordon exhibited a number of beautiful and newly-devised instruments for his researches on electrical induction, and M. Janssen on two occasions brought forward some of the further results gleaned in the field of astronomical physics, in which his name is so justly renowned. A paper by Prof. H. A. Newton, of Yale College, on the Direct Motion of Periodic Comets of Short Period, presented many points of the highest interest, and is a most valuable contribution to theoretical physical astronomy. The President of the Section, Mr. Johnstone Stoney, F.R.S., communicated several valuable papers on Molecular Physics and on Spectroscopy. Dr. Graham reported some excellent observations on Atmospheric Electricity from Madeira; and Prof. S. P. Thompson dealt with the Retardation of Phase of Vibrations in the Telephone, and showed an instrument called the pseudophone, for producing acoustic illusions.

In the Department of Mathematics, which sat on Saturday morning, several important communications were made.

In Section B (Chemistry) Prof. Dewar presided, and contributed several papers. His address was solely concerned with industrial chemistry, and does not seem to have contained much of novelty. Naturally, metallurgy has claimed prominence in this industrial centre, and chemical visitors have had ample opportunity of visiting the various works in the neighbourhood. Amongst the establishments which have thus drawn large numbers of visitors are the Bessemer steel works of Messrs. Steel and Tozer, and the electroplating factory of Messrs. Walker and Hall.

The Biologists and Anatomists have kept Section D a centre of attraction. The addresses of Prof. Mivart and Dr. Pye-Smith are each admirable; and the quiet but effective sarcasm with which the latter exposed the fallacies of anti-vivisection agitators drew hearty applause. Dr. Tylor's address to the Department of Anthropology was no less interesting, and was listened to attentively, as were Sir J. Lubbock on Fruit and Seeds, and Dr. Crichton-Browne on the Influence of Domestication on Brain-Growth.

Section E (Geography) has been favoured by the presence of several distinguished travellers, Commander Cameron, Major Serpa Pinto, and Count S. de Brazza, all African explorers of note, having given papers. Afghan and Zululand have furnished themes of burning discussion to this Section.

The Economic Section appears to have taken a new lease of active life, and has seldom presented more animation.

In the Mechanical Section the subjects of Friction at High Velocities, the Patent Laws, Hot Air Blast, and Electric Lighting, have claimed attention, and M. Bergeron explained the principles of Francy's Fireless Locomotive.

In spite of the drawback of bad and inconvenient streets and poor hotel accommodation, the Association has been fairly accommodated, and the reception accorded has been most hearty. The Mayor, the Master Cutler, and many other citizens of prominence, have been unremitting in their efforts; and the praises of Yorkshire hospitality are loudly sung. The reception of the Mayor at the *soirée* of Thursday evening in the Cutlers' Hall was very brilliant. The scientific *soirée* of Tuesday evening was no less successful, though the pleasure of the occasion was at one moment threatened by an unfortunate difference of opinion between local and general authorities on the subject of dancing, concerning which, however, a compromise was subsequently arranged.

The Mayor's banquet on Saturday evening was attended by about 340 guests, and was highly successful. Mr. Mundella, in replying to the toast of the Houses of Parliament, proposed by Dr. Odling, deplored the lack of

sympathy between Parliament and science, and declared that he had sat up late so often in support of the Ancient Monuments Bill of Sir J. Lubbock, that he had almost become an ancient monument himself. The Archbishop of York responded for the Clergy, and General Thuillier and Commander Cameron for the Army and Navy. Dr. Haughton, of Dublin, was as amusing as ever in proposing the health of the Presidents of Sections.

Many little excursions have been organised during the week to places of interest. The Saturday excursions were eminently successful, and the Thursday excursions, including expeditions to the Peak, Castleton, &c., were very popular and largely attended.

The reports of the sectional proceedings in the local papers seem to us unusually meagre, though the space devoted to the Association both in provincial and in London papers becomes each year increasingly great. The *Times* alone this year has had several leaders on the Association generally, as well as on the principal addresses, and it is gratifying to notice the decided improvement not only in the knowledge displayed in these articles, but also in the attitude of the leading paper towards science. In a somewhat hysterical article on Prof. Allman's address, the *Observer* of last Sunday seems to forget that science has all sorts of followers, and that the real workers rarely come before the public. Notwithstanding the apparently complete ignorance of the writer in the *Observer* as to what science really is, we cannot help agreeing with much that he says as to the present condition of the Association, and the urgent need of reform in its method of work, if it is not rapidly to degenerate into a "scientific garden party."

It is gratifying to notice the change of attitude of the Archbishop of York towards science and its followers, to judge both from the sermon of Sunday and his speech at the Mayor's banquet. He evidently no longer regards the foremost of the workers in science as emissaries of the "Evil One," but rather as fellow-workers with "the Church" for the highest good of humanity. To those who heard, on a Sunday, years ago, Prof. Huxley's famous address in Edinburgh, on the Physical Basis of Life, and the introductory references to an address delivered a few days previously by the Archbishop, this change of attitude must be very significant.

A committee was appointed last year for the consideration of the organisation of the Natural History Museum in connection with its removal to South Kensington. A memorial was forwarded by the Council to the First Lord of the Treasury, who could not receive a deputation, but who forwarded a reply.

The memorial referred to the fact that the Royal Commission on Science had recommended that the occasion of the removal of the collections to South Kensington New Museum be taken advantage of to effect a change in the official administration of that division of the British Museum; that a director of the collections and a board of visitors be appointed. The memorialists stated that notwithstanding these expressions of opinion, an Act had been passed by Parliament for the removal of the collection to South Kensington, but no change had been made in the mode of the administration. They called attention to the fact that it was at variance with the recommendations of the Royal Commissioners, and urged upon her Majesty's Government to take steps to carry out these recommendations, as the administration of the collections was of the utmost importance to the future progress of natural history in this country.

Capt. Douglas Galton read at the meeting of Council the reply received from the Treasury, which states that—

"My Lords, while fully agreeing with you, that the question of the administration of these collections is one of the utmost importance as regards the future progress of natural history in this country, are also of opinion that there is nothing which, on a point requiring so much con-

sideration, calls for instant decision. They think that the reasons which led them in 1877 to constitute the present Meteorological Council, rather than to create a new Government department, are not without weight in regard to displacing the trustees of the British Museum. My Lords do not intend to propose to Parliament any immediate change in the management of these collections, and they would be glad to find that the reasons which had led to the recommendations of the Royal Commission had been found to be capable of being met without any serious departure from the principles of a more or less independent trust."

It was generally agreed that this reply was very disappointing, and after remarks from various Members of Council, Prof. Huxley drew attention to the paragraph in the Treasury's letter where the manner in which the meteorological body had been dealt with, was mentioned, and said that to make any such comparison would be simply ludicrous. The Meteorological Committee was composed of the greatest experts in meteorology within the three kingdoms. He desired to speak with every respect of such distinguished persons as the trustees of the British Museum, but he could not say that they stood in the same position to natural history. There was no point of resemblance in referring to the placing of meteorology in the hands of a meteorological council. If the Treasury was prepared to place the management of the natural history department of the British Museum in the hands of a body which corresponded in zoology to what meteorology was in the meteorological council, that was an exceedingly intelligent proposition, and the General Committee should consider it carefully before they said anything against it, for it came very much to what the committee was advocating. As the Treasury appeared to be still fluid and mobile, it might be well that the General Committee replied to the letter, saying that the Treasury themselves suggested a basis on which they could construct an administration which would be perfectly satisfactory to the British Association, and therefore it would be perfectly agreeable to all round.

The sum received for tickets this year has been 1,425/. Next year the Association meets at Swansea, when Prof. Ramsay will be President. In 1881 the Association celebrates its jubilee at York—a year behind time.

The following grants have been made:—

A—Mathematics and Physics

Lodge, Dr.—New Form of High Insulation Key	10
Adams, Prof.—Standard of White Light	20
Everett, Prof.—Underground Temperature	10
Joule, Dr.—Determination of the Mechanical Equivalent of Heat	50
Thomson, Sir W.—Elasticity of wire	50
Glaisher, Mr.—Luminous Meteors	30
Darwin, Mr. G. H.—Lunar Disturbance of Gravity	30
Sylvester, Prof.—Fundamental Invariants	50
Perry, Mr. J.—Laws of Water Friction	20
Ayrton, Mr. W. E.—Specific Inductive Capacity of Sprengel Vacuum	20
Haughton, Rev. Prof.—Completion of Tables of Sun-heat Co-efficients	50
Forbes, Prof. G.—Instrument for Detection of Fire-damp in Mines	10
Thomson, Mr. J. M.—Inductive Capacity of Crystals and Paraffines	25

B—Chemistry

Dewar, Prof.—Spectrum Analysis	10
Wallace, Dr.—Development of Light from Coal-gas	10

C—Geology

Duncan, Prof. P. M.—Report on Carboniferous Polyzoa	10
Adam, Prof. A. L.—Caves of South Ireland	10
Seeley, Prof.—Viviparous Nature of Ichthyosaurus	10
Evans, Mr. John—Kent's Cavern Exploration	50
Evans, Mr. John.—Geological Record	100
Williamson, Prof. W. C.—Miocene Flora of the Basalt of North Ireland	15
Hull, Prof.—Underground Waters of Permian Formation	5

D—Biology

Pye-Smith, Dr.—Elimination of Nitrogen by Bodily Exercise	50
Lane-Fox, General M.—Anthropological Notes	20
Stainton, Mr.—Record of Zoological Literature	100
Foster, Dr. M.—Table at Zoological Station at Naples	75
Gamgee, Dr. A.—Investigation of the Geology and Zoology of Mexico	50
Lubbock, Sir J.—Excavations at Port Stewart	15

F—Statistics and Economic Science

Farr, Dr.—Anthropometry	50
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G—Mechanics

Bramwell, Dr.—Patent Laws	5
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SECTION A

MATHEMATICAL AND PHYSICAL

OPENING ADDRESS BY G. JOHNSTONE STONEY, M.A., F.R.S., SECRETARY TO THE QUEEN'S UNIVERSITY IN IRELAND

IN order that we may understand the present position of natural science upon the earth, we must remember that the universe is in itself one great whole, which includes minds no less than bodies, for thought is as much a phenomenon of what really exists as motion. But though the universe be but one, man with his limited powers is unable to treat it as such, but has to push his investigation of nature when and where he can. Thus have arisen many sciences which were at first quite isolated. Their separate condition is a mark of the feebleness of our powers of investigation. Their gradual convergence, and especially where any complete contact can be established between them, is the mark that our advancing knowledge is penetrating deeper.

That there are many sciences of nature, instead of one science of nature, has its relation, then, to human imperfection. But the coalescence of sciences has commenced, and is steadily taking place; magnetism is no longer isolated from electricity, nor light from heat, nor the power of thinking from the condition of the brain. In all such cases we have got nearer to understanding what is really going on in nature. There are already many such achievements of science, but nevertheless it remains true that human powers of investigation are so narrow, and the use we have made of them up to the present is so short of what we may reasonably look for in the future, that the sciences of nature are still many, and most of them stand lamentably aloof from one another.

We find, then, in the present passing condition of our knowledge, one group of sciences which investigate the phenomena of consciousness, another distinct group of the biological sciences, and a third, the group of the physical sciences. These are all but parts of the one great investigation of nature, but for the present they exist almost disconnected, as separate provinces of human inquiry.

After remarking on the complication of the Biological Sciences Prof. Stoney said:—

In the rest of the study of nature we are not embarrassed by the phenomena of life, and many mysteries therefore stand aside out of our path. Here lies the domain of the physical sciences. It is here that the mind of man has best been able to cope with the realities of the Universe, and in which its greatest achievements have been effected. It is here that exact reasoning finds a predominant place.

The process of investigation in the exact sciences is fundamentally one in all cases. It has been well described by Mill in the Third Book of his Logic. Nevertheless it is notorious that minds which are well fitted for some branches of physical inquiry, find difficulty—sometimes insuperable difficulty—in pursuing others. It is not every eminent mathematician who would have made an equally good chemist, or *vice versa*. This is because there exists a practical distinction separating the investigations of exact science into two well-marked classes when they are viewed, not as they are in themselves, but in their relation to the powers of us, human beings. I refer to the distinction between the experimental method or the method of observation, on the one hand, and the deductive method or the method of reasoning, on the other. All valid investigations in exact science appeal to what can be directly perceived, and all lead to a conclusion which can be reasoned out from it; but there are some of these investigations in which the main difficulty consists in

making the appeal to the senses, and there are others in which the main difficulty lies in the process of reasoning.

To contend with these difficulties successfully requires very different qualities of mind and body. In experimental science the powers principally called into requisition are readiness and closeness of observation, dexterity in manipulation, skill in devising expedients, accuracy in making adjustments, and great patience. It also requires that the investigator should have an accurate memory of what else he has witnessed resembling the phenomenon under observation, that he should be quick to detect every point of agreement and difference that can be perceived, and be skilful to select those which are significant and to employ them as materials for prevision to guide his further proceedings. But the strain on the reasoning powers is generally less, often of trifling amount. The question is put to Nature, and it is Nature usually that gives the bulk of the answer. The most striking monument of splendid achievements by the experimental method of investigation unaided by the deductive method is to be found in the science of chemistry.

An equally typical instance of the power of the deductive method is the science of mechanics. This science, which has sunk deeper into the secrets of Nature than any other science, and which is the science towards which all other physical sciences are at present more or less gravitating, is essentially deductive. There is little or no difficulty about its fundamental data. They are facts of Nature, so patent to all men, and so indelibly implanted in human conception, that some persons have supposed that we have an intuitive perception of them. But, while the materials from which the mind is to work are thus easily obtained, it has taxed to the utmost the reasoning powers of understandings like Newton's to evolve the few consequences of them which are already known, and the investigator has to call to his assistance every aid to prolonged consecutive thought which mathematicians can devise.

In grappling with the problems of Nature we are seldom allowed the choice of the method of investigation we shall employ. This is commonly settled for us and not by us. Where we cannot advance without further information, we must make further observations, *i.e.*, we must employ the experimental method, the appeal *ad experientiam*; where we cannot advance without understanding better what the information we possess really amounts to, we must employ the deductive method. . . .

After referring to Kirchoff's investigations as an example Prof. Stoney said:—Wherever data are known exactly, these inferences from these data, however remote, may be depended upon as corresponding with what actually occurs in nature. And if, in such cases, the mind of man has proved equal to the task of drawing inferences which can effectually grapple with the problems he finds around him in the universe—which is, alas, as yet but too seldom—then will the deductive method, our plummet, explore depths in the great ocean of existence which our anchors of experiment could not have reached.

The distinction which is here made between deductive and experimental investigations would have no place in a logical system. But it has direct reference to human convenience, and derives its importance from this circumstance. It is obvious, too, that an investigation may partake of both characters—that it may require all the powers of the scientific observer to get at the facts, or even to appreciate them, and all the resources of the mathematician to elicit the consequences of them. For instance, on beginning his electrical studies the student of nature must master a mixed experimental and deductive inquiry to get at the elementary fact that free electricity resides either at or outside the surfaces of conductors; and he must engage in a further inquiry, and one only within the reach of a trained mind, to deduce from this the law of the inverse square. And, again, no full appreciation or even intelligent use of the common electrostatic and electrodynamic measures, which he meets at the threshold of his electrical studies, is within the reach of the mere experimentalist or of the mere theorist. And if this treacherous ground lies before the immature student at his entrance, what shall we say of the bogs he struggles into as he advances? We are perpetually meeting with inquiries of this mixed character in electricity and some of the other physical sciences, but they are comparatively rare in either mechanics or chemistry, and none that is difficult lies in the path of the beginner. How many students are there who are made to slur over the above and a multitude of similar difficulties, and who are told that they are learning science, when in fact what they are really learning is the pernicious habit of being content to see nature through a fog or through other men's mental eyes.

In mechanics valuable progress can be made by the mere mathematician, the student of deductive science; and in chemistry similar progress can be made by the mere experimentalist. Of all the physical sciences these are the most purely deductive and the most purely experimental. What I desire particularly to invite attention to is that the two great methods of investigation may best be acquired in these two sciences, and that for a really sound grasp of the remaining physical sciences, and especially with a view to further advance in physical science, a command of both methods of investigation is essential. But then, to bestow this invaluable power on the scientific student, the great science of mechanics must be presented to him in its own true form, and not degraded by the vile art of avoiding the legitimate use of the infinitesimal calculus in order to comply with the ill-judged conditions of some examination; and our practical chemistry must be made something more scientific than instruction in the lucrative art of the analyst.

We must bear in mind, too, that either method of investigation may be misapplied, and that this is a risk carefully to be guarded against. The deductive method, when misapplied, lands us in speculation, the experimental method becomes empiricism; and it so happens that the sciences of mechanics and chemistry are not only monuments of the power of the two great methods of investigation, but instructive examples of their weakness also. For in chemistry scarce any attempt at prolonged reasoning, carrying us by any lengthened flight to a distance from the experiments, can be relied on. The result has seldom risen to anything better than speculation. And on the other hand, in mechanics conclusions which depend on experiments only are empirical; that is, they are deficient in accuracy and their relation to the other phenomena of the science is left in darkness. Here, then, we find in these two sciences not only how strong these two methods of investigation are, but how weak they may become if misapplied. . . .

I have sought to show that it is in the study of mechanics and the practice of chemistry that the two great methods of investigation may best be acquired. In them they may be studied separately, by steps of graduated difficulty, and with a superabundance of materials; and each of them supplies the necessary cautions with respect to the method which is all-powerful in the other. No scientific man is really equipped for the pursuits in which both methods have to be employed till he has separately acquired a grasp of each. For it is only then that he will be armed against the errors which lead so many to mistake empiricism on the one hand and speculation on the other for solid science, or to underrate solid science, mistaking it for speculation. Nor is it only in his scientific occupations that he will derive benefit from this training. All exact reasoning, whether in science or in common life, belongs to these great divisions; and in the numberless instances in which we must be satisfied with reasoning which falls short of being exact, our only safety lies in having by the practice of exact reasoning, both deductive and experimental, attained to that intellectual tact and caution which alone will enable us to handle with safety the sharp and slippery tool. It is thus I am persuaded that a sound judgment with regard to truth may best be acquired by man or woman; and soundness of judgment is the noblest endowment of man's understanding, just as veracity is first among his virtues.

SECTION D

BIOLOGY

Department of Anatomy and Physiology

ADDRESS BY P. H. PYE-SMITH, B.A., M.D., VICE-PRESIDENT OF THE SECTION

THE Association to which we belong seeks to advance Natural Science, that is, accurate knowledge of the material world, by the following means:—

First.—By bringing together men who are engaged in the various fields of science indicated by our several sections, by promoting friendship between them, by giving opportunity for discussion on points of difference, by encouraging obscure but genuine labourers with the applause of the leaders whom they have learnt to venerate, and by fostering that feeling of respect for other branches of science, that knowledge of and interest in their progress, which chiefly marks the liberality of scientific study.

Secondly.—The Association provides funds, which, though

small in amount, are great in worth, from the mode of their distribution; and serve in a limited degree as an encouragement, though not an endowment, of research. One proof of the value of this method of subsidising unremunerative work by small grants distributed by the master workmen themselves is given by the fact that the sum of 4,000*l.* annually contributed by the Government of the United Kingdom for the endowment of research is distributed on the same plan by a Committee of the Royal Society.

The Third most important aim of our Association is, "to obtain a more general attention to the objects and methods of science, and the removal of any disadvantages of a public kind which impede its progress." It is for this reason that the Association travels from one to another of the great centres of population and intellectual activity of the kingdom. Local scientific societies and local museums are generated and regenerated in its path, local industries are for a time raised to a higher level than that of money-getting, and every artisan may learn how his own craft depends upon knowledge of the facts of nature, and how he forms part of the great system of applied science which is subduing the earth and all its powers to the use of man. We wish to make science popular, not by deceiving idlers into the belief that any thorough knowledge can be easy, but by exciting interest in its objects and appreciation of its methods. In the popular evening lectures you will hear those who are best qualified to speak upon their several subjects, not preaching with the dry austerity of a pedant, but bringing their own enthusiasm to kindle a contagious fire in those who hear them.

Endeavouring to aid in these objects, I shall in this introductory address offer you some considerations upon the bearing of biology in general, and anatomy and physiology in particular, upon national well-being and public interests.

Biology is the science of the structure, the functions, the distribution, and the succession in time of all living beings. If the proper study of mankind be man, he has learnt late in the inquiry that he can only understand himself by recognising that he is but one in the vast network of organic creation; that intelligible human anatomy must be based upon comparative anatomy; that human physiology can only be approached as a branch of general physiology, and that even the humblest mould or seaweed may furnish help to explain the most important problems of human existence.

The branch of physiology which is concerned with man, not as an individual, but a family, the branch which we now call Anthropology, is obviously related to practical politics, and it was not without reason that the late illustrious pathologist Rokitsansky began a speech in the Upper House of the Austrian Parliament on the autonomy of the Bohemian nation with the words, "The question really is whether the doctrine of Darwin be true or no."

In another department, that of psychology, the physiology of the nervous system has already thrown more light upon the mysterious phenomena of consciousness than was gained by the acutest minds of all ages without the help of anatomical methods.

All the improvements of modern agriculture and stock-breeding rest upon more or less fully understood scientific principles, and the more perfectly the results have been first worked out in the laboratory the more safe and the more lucrative will be their application in the field.¹

Still more important is the relation of physiology to the national health. The commonplaces of hygiene which are now, one may be thankful to say, taught, if not practised, in almost every schoolroom and factory in England, are the direct results of the abstruse researches of Boyle and Priestley, of Lavoisier and Pasteur. Ages of experience did not teach mankind the value of fresh air, or the innocence of clean water. Indeed, I have myself heard astonishment expressed by a German professor at the peculiar immunity with which English skins will bear the daily and unstinted application of soap and water.

If the art of keeping a community in health is but the application of plain physiological laws, it is no less true that the art of restoring the health, curative as distinct from preventive medicine, rests upon the same basis. In former days the physician was one who recognised what he called the disease of his patient, who referred to his books of precedents as a lawyer to his statutes, and who prescribed a proper remedy to cast out

¹ I need only refer to the fruitful labours of Mr. Lawes and Dr. Gilbert in this direction.

the disease. We now know that disease is, as the name implies, a purely subjective conception. The disease of a host is the health of the parasite, and we cure a human sufferer by poisoning the animals or plants which interfere with his comfort. The same changes which in the old man are the natural steps of decay, the absence of which after a certain age would be truly pathological, are the cause of acute disease in the young. Pathology has no laws distinct from those of physiology.

When these now obvious considerations are thoroughly understood, it clearly follows that all "systems of medicine" are in their very nature condemned. All that the art of medicine can do is to apply a knowledge of natural laws, of mechanics, and of hydrostatics, of botany and zoology, of chemistry and electricity, of the behaviour of living cells and organs when subjected to the influence of heat and of cold, of acids and alkalis, of alcohols and ethers, of narcotics and stimulants, so as to modify certain deviations from ordinary structure and function which are productive of pain, or discomfort, or death. It is, therefore, plain that rational medicine, or keeping right and setting right the human body, must rest upon a knowledge of its structure and its actions, just as a steam-engine or a watch cannot be mended upon general principles, but only by one who is familiar with their construction and working, and who can detect the source of their irregularity.

An objector may say:—"Admitting that medicine is an art, it is a purely empirical art. You cannot detect the origin of many of the maladies which you are yet able to cure; your best remedies have not been obtained by scientific experiment, but by chance, observation, and accumulated experience; and if you doctors would give more time to practical therapeutics, that is, to finding out what is good for the several aches and pains we complain of, you would spend your time better than in abstruse researches into microscopic anatomy or the properties of a dead frog's muscle."

The answer to the objection is an appeal to fact. For centuries so called observation and experience left medicine in the condition it occupied at the end of the seventeenth century. The progress of therapeutics is to be marked, not by the labours of "practical men," (who, by the way, are of all the most theoretical, only that their theories are wrong), but by the, at first sight, unconnected studies of Descartes and Newton, of Hooke and Grew, of Lavoisier and Davy and Volta, of Marshall Hall and Johannes Müller.

The history of science proves that unconnected, unsystematic, inaccurate observations are worth nothing. For untold ages men have had ample opportunities of studying the indications of the weather, and have felt the utmost desire to obtain a knowledge of what they portend. Yet it may fairly be said that nothing had been done to the purpose, until combined and systematic observations were made in this country and America.

The fact is, that popular notions do not rest upon experience or observation. They rest, with scarcely an exception, upon metaphysical theories. In dealing with uneducated persons, both of the lower and higher ranks, physicians find abundance of theories as to the nature and the origin of disease, and of suggestions as to its cure. The only thing which would be of value is what we can scarcely ever get, an accurate observation of what they see and feel. Every fallacy of popular medicine, every solemn medical imposture, is the ghost of some long defunct doctrine of the schools. Therefore it is that common experience is almost absolutely useless in practical arts. They, without exception, depend for their progress upon the advance of science, that is, upon methodical, continuous, and scrupulously accurate observations and experiments.

Many important advances in the practice of medicine have been gained by direct and intentional experiments instituted with a therapeutical object. Such was the Hunterian operation for aneurism, the process of skin-grafting, and superiosteal operations; such was the administration of chloroform and the introduction of nitrite of amyl, chloral hydrate, and carbolic acid. Such direct experiments still go on, and among them deserve mention for the skill and the untiring patience with which they were carried out, those investigations upon the action of various drugs on the secretion of bile for which we are indebted to Prof. Rutherford and his coadjutors. Even apparently accidental discoveries were not made accidentally. Hundreds of country surgeons must have been familiar with the cow-pox, and have seen examples of the immunity it conferred from the more terrible variola, but he who discovered vaccination was no falsely called practical man. He was a man of science, the

friend of Hunter and of Cavendish, an anatomist and natural philosopher. The fruits of Jenner's discovery are spread over the whole earth. This humble village doctor has saved more lives than the most glorious conqueror destroyed, but his name is little honoured, and the only monument to his memory has been banished from association with vulgar kings and skilful homicides to an obscure corner of the great city, where his only homage is the health and beauty of the children who play around his statue.

But after all, it is not so much by direct and immediate contributions to the art of healing that physiology has vindicated her ancient title of the institutes of medicine, numerous and important as these contributions have been. It is still more by the scientific spirit which has transformed the empty learning so justly ridiculed by Molière and Le Sage into the practical efficiency of modern surgery. Let me give an instance of what I mean. The notion of measuring the temperature of the body is simple enough, and the rough observation that in inflammation the temperature is raised had led to the various terms by which it was denoted in ancient medicine, and to numberless theories now happily forgotten. But although the thermometer was well known, and had been applied by many scientific physicians, notably by De Haen, by Dr. John Davy, and by Sir Benjamin Brodie, yet the practical value of the clinical thermometer which now every practitioner carries in his pocket was not understood until the other day. Those only who had been trained in accurate physical and physiological investigations, who had learned the worse than uselessness of "rough observation," were able to see the enormous importance of clinical thermometry. This most practical of modern improvements in medicine would never have been dreamt of by "practical men": we owe it to the scientific training of German laboratories.

If physiology is of such great national importance, if the necessity of experimental research is so vital to the common national wealth, to agriculture and commerce, to health and well-being, ought not its well-ascertained results to be taught in our common schools, and its prosecution directly encouraged by the State?

There is no question of the great importance of children being taught the rudimentary laws of health, the bodily evils of dirt and sloth and vice, the excellence of temperance, the danger of the first inroads of disease. Such teaching, now broadcast in many excellent manuals as "The Personal Care of Health," by the late Dr. Parkes, and Dr. Bridges' "Catechism of Health," is no doubt extremely valuable, and happily is daily more and more diffused. But when beyond the direct utility of such knowledge, we attempt to make it an intellectual discipline, there are, I conceive, difficulties which will always prevent even elementary physiology from forming an important part of general education. First, there is the practical difficulty of the necessary dissections, next the impossibility of making physiology demonstrative, and thirdly, the abstruseness of the subject. It is impossible to have even an elementary knowledge of the laws of living beings without a very considerable familiarity with those of physics and of chemistry, and even in medical schools it requires all our efforts to prevent it degenerating into a mere dogmatic statement of results, or a laboured repetition of hearsay statements. As an intellectual discipline, for facility of demonstration, for the simplicity of the objects, their beauty and interest, their associations with the green lanes and broad moors of England, with the poetry of *Cymbeline* and *Lycidas*, with fairy tales and local folk-lore—Botany is to my mind the branch of natural science which is above all others to be chosen where one only can be taught. Next in importance I would place elementary physics, the knowledge of the simplest laws of masses at rest and in motion, of heat and light. Its great recommendations are its precision, its constant and useful illustrations in daily life, the interest it gives to the handicrafts and manufactures in which so large a number of English boys and girls are busied, and the necessity of such knowledge as the first step in acquiring all other natural sciences.

First, then, I would that every Sheffield girl should love flowers with the deep and abiding affection of familiar knowledge, and that every Sheffield lad should know every common plant in your beautiful woods and find his purest pleasure on the heights of Bell Hag and the broad expanse of Stanage Moor. And next I would that your workmen and workboys should know so much of mechanics that they may take an intelligent pride in your vast factories, and that in some of them may be

awakened the genius to which we trust to repeat in future generations the national services of Arkwright, and Watt, and Stevenson.

With regard to the endowment of research in biology, I must confess that I should be sorry to see it undertaken by government funds. That such investigations are of public interest, that they are difficult and expensive, and that at present they languish for want of adequate support, is all true. But this country is not so poor, nor our countrymen so wanting in public spirit, that we need appeal to the national purse to supply every ascertained want. Great as is the national importance of science, the nation is more important still; and even if that were the alternative, I would rather that we should indefinitely continue dependent on Germany for our knowledge than give up the local energy, the unofficial zeal which has made England what she is. Far better for the strength and the civilisation of the nation that a thousand pounds were raised every year for the endowment of unremunerative researches in this wealthy town of Sheffield than that ten thousand were paid you by a paternal monarch or an enlightened department.

But surely there is no need for us to go to Parliament for such sums as we require. In the first place, scientific men themselves show a good example of not asking before they give. There is the modest sum which we raise in this Association, there are the funds for helping research of the Royal Society, the Chemical Society, the British Medical Association, the Iron and Steel Institute, the Whitworth Scholarships. Next we have the resources of our Universities, which have scarcely begun to apply themselves to the task. I need do no more than allude to the Cavendish Laboratory, or to the Physiological School at Cambridge, where a simple college tutor, of rare ability, and of still more rare sympathy and energy, has in ten years, achieved results which we need not shrink from comparing with those of the great continental laboratories. The magnificent Museum of Anatomy, maintained by the College of Surgeons almost entirely out of their own funds, is another instance of private care for science to which we find no parallel abroad; and the Zoological Society wisely spends a large part of its income in prosecuting comparative anatomy, and in publishing its beautifully illustrated memoirs.

But besides the efforts of scientific bodies and the wealth of our national Universities, we may surely look to the public spirit of ancient companies and corporations to do something for the cause of science. In the middle ages our country was covered with parish churches by private munificence; in the sixteenth century most of our public and grammar schools were endowed; in later times our great religious and charitable societies were founded. May we not hope that, before the close of the present century, the discriminating knowledge which alone prevents gifts of money from being a curse instead of a blessing to a community, may lead to the establishment of libraries, and museums, and laboratories by universities and towns, which shall bear comparison, I will not say with those of Paris, or Leipsic, or Bonn, but with the poorer but scarcely less distinguished schools of Heidelberg and Göttingen, of Würzburg and of Utrecht?

Where we have institutions already under government control and patronage, let them be maintained as efficiently and liberally as possible. The British Museum, and its library, the Royal Observatory at Greenwich, and the Royal Gardens at Kew (happily preserved for the present from the short-sighted eagerness of those who would destroy their scientific value), these are great national institutions of which we are justly proud. Successive Governments will have enough to do to maintain their efficiency and to guard them from incompetent interference.

Whatever may be thought of the duty of the State directly to encourage the pursuit of animal and vegetable physiology, one would have supposed that at least what diplomatists call a benevolent neutrality, would be shown to a pursuit so labourious and costly, which demands trained workmen and the devotion of a lifetime, which is so important for the national wealth and health, and which, by reason, by experience, and by testimony, we know to be the only guarantee for advance in the various branches of the healing art. Why is it then that institutions which owe nothing to government assistance, and men who spend their time and talents in self-denying and unremunerative service for the public good, are not suffered to pursue their beneficent work in peace?

You know that certain persons who profess to be shocked by the methods of physiological research have succeeded in placing

this branch of science under as great disabilities as that sense of humour would allow, which so often redeems British ignorance from its most mischievous results.

The method that has given rise to so much excitement is the performance of experiments upon living animals. Now, if this were injurious to the greatest good of the greatest number of the community, or if freedom to perform these experiments interfered with the freedom of other persons to abstain from them, or if such experiments were forbidden by any religious or moral authority, by the Ten Commandments, or by Mr. Matthew Arnold, of course they must be given up; but equally, of course, the science of physiology must also come to a stop, and the farmer, the cattle-breeder, and the physician must be content with such knowledge or such ignorance as he at present possesses. I know it has been asserted that the science of the functions of living organs is quite independent of experiment upon living organs. But this is said by the same persons who have denied that the art of setting right the functions of the body when they go wrong has anything to do with the knowledge of what those functions are.

If you could be persuaded that chemistry can make progress without retorts and balances, that a geologist's hammer is a useless incumbrance, or that engineers can build bridges just as well by the rule of thumb as by the knowledge gained in a workshop, then you might believe that physiology also is independent of experiment.

It is absurd to object to the difficulties of the research or even the contradictory results sometimes obtained. The functions of a muscle or a gland are more complicated than those of water or gas, and their investigation needs greater skill, more caution and more frequent repetition. Imperfect experiments can lead to nothing but error; criticism from other physiologists, or from scientific men experienced in other branches of research, is not wanting and is always welcome. But vague assertion that further progress is impossible by the very means which have led to all our present knowledge, coming from those who "who are not of our school"—or any school, is undeserving of serious notice.

The real contention of course is a moral one, that we ought to relinquish the advantage of all experiments which are accompanied with pain to the creature experimented on. The botanist may serve his plants as he pleases, and even the animal physiologist may cut, or starve, or poison all sentient organisms which happen not to possess a backbone, and he may try experiments with all backboneed animals, including himself and his friends, so long as they do not hurt, but that must be the limit. On the most extreme humanitarian views no objection can be made to experiments upon animals in a state of insensibility to pain, and as these constitute, happily, the vast majority of physiological experiments, the question is narrowed to comparatively restricted limits. Is it wrong to inflict painful experiments upon animals for the sake of science? In the absence of any authority to appeal to, we can but judge of the matter by analogy. Now it has been the practice of all mankind, and is still allowed by the common consent both of law and feeling, that we should destroy by more or less painful means, that we should enslave and force to work, and mutilate by painful operations, and hunt to death, and wound, and lacerate, and torture the brute creation for the following objects:—for our own self-preservation, as when we offer a reward for the killing of tigers and snakes in India; for our comfort as when we poison or otherwise destroy internal parasites, and vermin, and rats, and rabbits. Our safety, our food, our convenience, our wealth, or our amusement: all these objects have been and are regarded by the great mass of mankind, and are held by the laws of every civilised country, to be sufficiently important to justify the infliction of pain or death upon animals in whatever numbers may be necessary. The only restriction which Christian morality or in certain cases recent legislation imposes upon such practices is, that no more pain shall be inflicted than is necessary for the object in view. Killing or hurting domestic animals when moved by passion or by the horrible delight which some depraved natures feel in the act of inflicting pain was until lately the only recognised transgression against the law of England. I trust I need not say that it is only under such restrictions that physiologists desire to work.¹ Any one who would inflict a single pang beyond what is necessary for a scientific object, or would by carelessness fail

to take due care of the animals he has to deal with, would be justly amenable to public reprobation. And, remember it is within these limits that the whole controversy lies, for after a long and patient examination of all that could be said by our accusers, the Royal Commission which was nominated for the purpose unanimously reported that in this country at least scientific experiments upon animals are free from abuse.

What is deliberately asserted is that within the restrictions which all humane persons impose upon themselves, it is lawful to inflict pain or death upon animals for profit or for sport, for money or for pastime; that property and sport are in England sacred things; but that the practices which they justify are unjustifiable when pursued with the object of increasing human knowledge or of relieving human suffering.

Of those persons who answer that they consider vivisection for the sake of sport to be almost as detestable as vivisection for the sake of duty, I would only ask first that they should deal impartially with both offences, and secondly that since in the one case their opinions are opposed to the practice of genteel society, and in the other to the convictions of all who are qualified to judge, they should at least contemplate the possibility of being mistaken. Putting the question of field sports altogether aside, you know perfectly well that in every village in England an extremely painful mutilation is constantly performed upon domestic animals in no registered laboratory, under no anaesthetics, and with no object but the convenience and profit of the owner. You remember how when an epidemic threatened the destruction of valuable property, every booby peer now eager to stop, so far as in him lay, the advance of knowledge, was no less eager to have carried out at the public expense any slaughter and any experiments, painful or otherwise, which would save his pocket.

But you will say: all this seems reasonable enough; but if so, how do you account for the prejudice against you, what has induced so many amiable and otherwise sane persons to join in the outcry against physiology?

First, I answer, it is due to the most frequent cause of folly—Ignorance. Many persons supposed to be educated are so destitute of the most ordinary conceptions of natural science that they do not understand the necessity for experiments. So little do they appreciate the difference between formal knowledge and real knowledge, that a distinguished statesman once assured me that he would as soon have his leg set by a man who had gained what he called his knowledge from books, as by one who had "walked the hospitals." Next, there is the vulgar dislike of whatever is not obviously and immediately useful. When knowledge for its own sake is in question, those of the baser sort are always ready to cry with equal ignorance of literature and of science, "*cui bono?*"

In another class of persons, less ignorant and less stupid than these two, opposition to physiological experiments appears to spring from what may fairly be stigmatised as Sentiment, that is to say, excitability, rather than deep feeling, uncontrolled by reason. People first gratify their fancy by calling cats and dogs our fellow creatures, which, in one sense, undoubtedly they are, and then, by the familiar fallacy of an ambiguous middle term, argue that it is cruel to put our fellow creatures to pain; or, as some would add, to reduce them to slavery, or to use them in any way for our own, rather than their good. Such persons compel their fellow creatures to drag them through the streets, they eat their fellow creatures when sufficiently vivisected to be palatable, and then find philosophical excuses for those who kill their fellow creatures for fun. But they are properly shocked when their fellow creatures are hurt or killed for the benefit of mankind. Such persons have been accused of feminine weakness; but I must say that I have never found an intelligent woman who could not see the rights of the case when fairly explained to her, whereas I have met a few men who on this, as in other matters, consistently refuse to give up to argument the notions which were formed by prejudice.

This sentiment is, I admit, the degradation of just feeling. To many unaffectedly compassionate hearts there is a peculiar pang in thinking of suffering which is deliberately inflicted, with only the justification of duty, instead of the excuse of ignorance or passion. They see in the helplessness of the dumb animals an appeal for pity, almost like that of childhood, and are justly indignant with the selfish cruelty so often exercised upon them. All honour to the efforts which have banished so many cruel sports from England; all honour to the Society which seeks to prevent cruelty to animals. If it can

¹ They are, in fact, the very limits that were put on record by this Association long before the agitation against physiology began. See Report for 1871, p. 144.

point to any additional means by which the sufferings of animals in the cause of science can be diminished, we shall be anxious to adopt them. If it can point to any abuse in one of our laboratories, we will hasten to correct it. This society has honourably declared that they know of none. That physiologists have been heedless, or even callous, in their experiments upon animals in past times, when men were strangely insensible even to human suffering, or in countries where a healthy result of Christian civilisation has not yet been seen in habitual gentleness to animals, I need not deny. Such cases have been eagerly sought and sometimes most unfairly judged. Only lately a learned body felt itself not strong enough to retain the admittedly invaluable services of an eminent foreigner, who had once admitted that when absorbed in scientific and beneficent researches he lost sight of any pain that might be inflicted.¹ Is not this the very excuse which is held valid in the case of sport? Doubtless we ought to be ever mindful of every branch of duty, but such occasional forgetfulness does not show hardness of heart. It is an excusable weakness for a student of medicine to shudder or to faint at the sight of blood, but he learns that this merely physical sensibility becomes selfish and mischievous if indulged: he is taught to suppress all such exhibition of emotion, and to let it stimulate without paralysing his efforts to relieve. But no one surely would think the hysterical youth more truly humane than the surgeon whose compassion is shown in the very firmness with which he inflicts a temporary pain for an ultimate good.

I have hitherto rested the whole argument upon the lawfulness of inflicting pain and death upon the lower animals for the sake of science and humanity, but as a matter of fact I may again assure those who, while assenting to the justice of the plea, yet shrink from what it may involve, that the great majority of experiments upon animals are rendered painless, and that the remainder are mostly those experiments which are most immediately and directly subservient to medical art, and happily even these are generally productive rather of discomfort than of pain. Let me give you an example of such a vivisection, far more painful than the immense majority of those of the laboratory. Suppose a country surgeon were sent for late at night to some case of urgent peril; knowing that his ride is for life or death, and unsparing of himself or his horse, he rides him to the utmost limits of endurance, and beyond: who would not applaud the action? Those only who appear deliberately to believe that our life is worth less than that of many sparrows, those legislators only who look forward to the time when wars will cease, not because of human slaughter, of devastated homes, of all the horrors which the world has endured for centuries, but because of the cruelties to which the horses in the artillery are subjected. We, who are familiar with human suffering and sorrow, which our knowledge is all too feeble to prevent, best understand how in testing some new remedy on a less precious fellow creature than a man, one who is truly humane may be tempted to forget the comparatively trivial suffering of a rabbit or a frog.

But some enthusiastic opponent will say, "I cannot pretend to doubt that these experiments are in every sense of the word useful, but we ought not to purchase the benefit they confer by inflicting pain upon innocent creatures. I would sign a petition to-morrow to put down all field sports by law, I would allow no operation upon domestic animals, and I will abstain from all animal food until I am certain that I can eat creatures which have been killed without suffering pain. But if I were lying at the point of death, and you brought an animal to my bedside and assured me that by putting it to pain my life would be saved, I would refuse to purchase it on such cruel terms." We may hope that the excellent person who made this heroic profession would in the hour of trial be better advised, but if not we may surely reply, "Right reverend sir, you are the best judge of the value of your own life, and if you think proper to sacrifice it to the comfort of a guinea-pig we must submit to the loss with such resignation as we can muster; but when you say that in obedience to this silly whim you will let your dearest friend suffer, allow the sacrifice of the most important life, and forbid those studies which have already rescued multitudes from deformity and misery and death, then those of us who have to do

with the real responsibilities of life, and on whom presses the awful sense of impotence to which our defective science too often leaves us, answer that we too have duties to fulfil, and to the best of our power we mean conscientiously to fulfil them.

There is, I fear, another reason which animates much of the opposition to physiological experiments. It is nothing else than aversion from the methods and the results of science. It may be that an excuse for this dislike has been furnished by the pretence of false science, and the arrogance of much even which is true. But surely, no reasonable creature, from such trivial irritation, can deliberately wish to check the progress of accurate knowledge by observation and experiment. There are, indeed, some who, fearing (as I think prudently) that, "while a little philosophy inclineth men to atheism, depth in philosophy bringeth men's mind's about to religion," and desiring to subject the human mind to a bondage as hard and more degrading than that of mediæval Rome, would gladly call off interest from the unremunerative labours which are prompted only by the thirst for knowledge and faith in the possibility of learning more and more of the divine order of the world, to pursuits which bring obvious and material utility. There are those again, who, fearing (as I think foolishly) that increasing knowledge of this divine order will lower our admiration of its beauty, or that the better a man understands the laws of God the more likely he is to break them, have an unfeigned dislike for natural science in general, and for biology in particular. They repeat over again the error of which the Dominican friars, with far greater excuse, were guilty when they imprisoned Galileo. If any such are here, may I venture to tell them—in quietness and in confidence is your strength: the vast fabric of Christian morals is in no danger of being overturned by the discovery of a new chemical method in the laboratory, or of a hitherto undescribed animalcule. If noisy attacks are made in the injured name of science, you have only to wait, and you will see these attacks repelled by the true leaders of science themselves, or, at the worst, by the next generation. But if, leaving your secure fortress of defence, you come down with your rhetoric and your sentiments, your *petitio principii*, your *ignoratio elenchi*, and all your familiar fallacies and tropes, thinking that with such weapons you can meet, on their own ground, men who have spent their lives in the study of science, then no wonder if you suffer grievous defeat. Happy for you if you learn, like another discomfited pilgrim, to betake yourselves to another "weapon."

But I imagine that some of my audience are saying: "This defence would have been necessary before the Royal Commission made their report; but when that was made, and affirmed the necessity of physiological experiments, and the groundlessness of accusations of cruelty against physiologists, when an act was passed which licenses physiological laboratories, under the very restrictions which you had already imposed upon yourselves, may we not regard the controversy as closed, and the result as satisfactory?"

I answer that I have taken up your time with this defence of physiological experiments partly because I would fain help, however feebly, in the enlightenment of the public conscience, but also because the result of recent legislation is not satisfactory.

Science does not work readily in fetters. A system of licences and certificates, numerous and complicated, obtained with trouble and delay, and revocable at the will of a Minister who may, by the accidents of party, be at any time amenable to anti-scientific influences, such a system adds serious difficulties to those already in the way of experiments.

Suppose, as an illustration, that certain persons opposed on various grounds to learning, and especially hostile to Greek, had attacked the study of Plato. They would point out the danger of modern ladies becoming as well read in his writings as was Lady Jane Grey. They would show that the laxity of modern manners was coincident with the popularity of the "Symposium" and that the notorious increase of infanticide was the result of the teaching of the "Republic." Associations for the total suppression of Plato would be formed, with hired advocates, and anonymous letters, and "leaflets," spreading a knowledge of his most objectionable passages. Scholars would be threatened with eternal punishment, and schoolmasters with the withdrawal of their pupils. Then a royal commission would be appointed—a great Latin scholar, a Whig and a Tory statesman (who, having taken a B.Sc. degree at Oxford would be impartially ignorant of Greek) the

¹ Fortunately, Dr. Klein, whose researches in microscopic anatomy and pathology are so well known and appreciated, knows that he retains the confidence and respect of his scientific brethren, and we hope that his honourable connection with the largest school of medicine in London, will strengthen other and closer ties in binding him to England.

most intelligent despiser of Plato who could be found, the master of a grammar school on the modern side, and (perhaps the most efficient of all) a lawyer, who knew nothing about Greek but hated cant. This commission would take evidence that the Platonic writings were not all immoral, that they had been quoted with approval by Fathers of the Church, that they were of great importance to literature and philosophy, and even to the elucidation of the Sacred Writings. It would also be proved that the Platonic Dialogues were far less immoral than multitudes of other widely circulated books, or than a French novel which one of the royal commissioners happened to be reading, and, lastly, that the morals of Greek scholars, and of clergymen who had read Plato at college, were not obviously degraded below those of other people. On the other hand, witnesses would depose that a knowledge of Plato was of no consequence to a student of philosophy; that if it were, the text was in so corrupt a condition that no two scholars agreed as to a single chapter, and that, after all, philosophy was of no practical use, least of all to clergymen. Others would affirm that though they had never read a line of him, they knew that his style was as vicious as his sentiments; and perhaps some cross-grained scholar might be found who, having once edited a play of Euripides, would declare that all studies in Greek literature ought to be restricted to the tragedians, and that for his part he had never opened any other authors and had never felt the want of them.

At last the commission would report that there was no question of the value of the works of Plato, that it would be mischievous and impracticable to prohibit their study, and that there was no evidence that schoolmasters habitually chose the least edifying passages as lessons for boys. Then what is called a compromise would be made. It would be enacted that Plato might be read, but only in colleges annually licensed for that purpose; that every one wishing to read must have a general certificate signed by certain professors, and setting forth his object, also to be renewed every year; and that special certificates might be severally obtained for reading certain excepted dialogues, for copying from them, for publishing them, or, in rare cases, for translating them.

However reasonably such a system might be administered, who can doubt the result would be a diminution of the number of scholars, and a check to the progress of learning?

Now this is what legislation has done for physiological experiments. The Act [39 and 40 Victoria] was hastily drawn and hurriedly discussed; for noble lords and honourable gentlemen who had been taught from childhood to vivisect for unscientific purposes were eager to hurry off to their own merry vivisections, for which they were ready provided with licence and certificates. And it works as might be expected. Some shrink from seeing their names figure in disreputable newspapers, and receiving more or less savagely abusive anonymous letters. Others have no laboratories, and find difficulty in licensing their houses. Others are refused the certificates they require.

In one case two thoroughly qualified men were anxious to carry out an important investigation on the treatment of snake-bites. They procured venomous snakes from a distance, and applied for the special certificates necessary. Considerable delay ensued; various objections were raised, and set at rest; and at last all the certificates were obtained; but meantime the snakes had died.

I must apologise for having detained you so long. The whole history of this controversy is melancholy but instructive.

To those of my audience who wish well to science, I hope that I may have made more clear the grounds on which vivisection is necessary and right, and thus fulfilled one of the chief objects of the Association—"to obtain the removal of any disadvantage of a public kind which impedes the progress of science."

To those working physiologists who have honoured me by their presence I would express the assurance that they have the confidence and the gratitude of the medical profession, witnesses at once competent and impartial, who know the difficulties and the value of such labours; and as to present discouragements, looking back to the obstacles which so long retarded the progress of our kindred science, anatomy, I may say

O passi graviora, dabit Deus his quoque finem.

When, in the earliest years of the Royal Society, Sir Christopher Wren and Dr. Lower made those experiments on

transfusion of blood which have at last proved so beneficent, there were not wanting shallow wittlings who scoffed at their researches. It was of them that Cowley wrote with a just indignation—

Whoever would depose Truth advance
Into the throne usurped from it,
Must feel at first the blows of ignorance
And the sharp points of envious wit.

You have at least escaped the latter penalty.

Dishonour fall on those
Who would to laughter or to scorn expose
So virtuous and so noble a design,
So human for its use, for knowledge so divine!

You wish your calumniators no greater dishonour than failure to do mischief. You wish for yourselves no other reward than "the wages of going on."

Department of Anthropology

ADDRESS BY EDWARD B. TYLOR, D.C.L., F.R.S.

IN surveying modern scientific opinion, the student is often reminded of a doctrine proclaimed in the ancient hymns of the Zend-Avesta, that of *Zrvāna akarana*, or "endless time." Our modern schemes of astronomy, geology, biology, are all framed on the assumption of past time immense in length. In fact, one reason why the latter sciences grew so slowly till almost our own day, was their being shackled by the bonds of a short chronology, allowing no room for the long successive periods through which it is now clear that the earth with its plants and animals passed into their present state. Even the Science of Man, though concerned with the later forms of being, belonging to times which geologists treat as almost modern, has nevertheless to deal with periods of time extending far back beyond the range of history and chronology.

Looking back 4,000 to 5,000 years, what is the appearance of mankind as disclosed to us by the Egyptian monuments and inscriptions? Several of the best-marked races of man were already in existence, including the brown Egyptian himself, the dark-white Semitic man of Assyria or Palestine, the Central African of two varieties, which travellers still find as distinct as ever, namely, the black or Negro proper, and the copper-coloured negroid, like the Bongo or Nyam-nyam of our own time. Indeed, the evidence accessible as to ancient races of man goes to prove that the causes which brought about their differences in types of skull, hair, skin, and constitution, did their chief work in times before history began. Since then the races which had become adapted to their geographical regions may have, on the whole, undergone little change while remaining there, but some alterations are traced as due to migration into new climates. Even these are difficult to follow, masked as they are by the more striking changes produced by intermarriage of races. Now the view that the races of man are to be accounted for as varied descendants of one original stock is zoologically probable from the close resemblance of all men in body and mind, and the freedom with which races intercross. If it was so, then the fact of the different races already existing early in the historical period compels the naturalist to look to a prehistoric period for their development to have taken place in. And considering how strongly differenced are the Negro and the Syrian, and how slowly such changes of complexion and feature take place within historical experience, this prehistoric period was probably of vast length. The evidence from the languages of the world points in the same direction. In times of ancient history we already meet with families of languages, such as the Aryan and the Semitic, and as later history goes on many other families of language come into view, such as the Bantu or Kafir of Africa, the Dravidian of South India, the Malayo-Polynesian, the Algonquin of North America, and other families. But what we do not find is the parent language of any of these families, the original language which all the other members are dialects of, so that this parent tongue should stand towards the rest in the relation which Latin holds to its descendants, Italian and French. It is, however, possible to work back by the method of philological comparison, so as to sketch the outlines of that early Aryan tongue which must have existed to produce Sanskrit and Persian, Greek and Latin, German, Russian, and Welsh, or the outlines of that early Semitic tongue which must have existed to produce Assyrian, Phœnician, Hebrew, and Arabic. Though such theoretical reconstructions of parent language from their descendants may only show a vague and shadowy likeness to the

reality, they give some idea of it. And what concerns us here is that theoretical early Aryan and Semitic, or other such reconstructed languages, do not bring our minds appreciably nearer to really primitive forms of speech. However far we get back, the signs of development from still earlier stages are there. The roots have mostly settled into forms which no longer show the reasons why they were originally chosen, while the inflexions only in part preserve traces of their original senses, and the whole structure is such as only a long-lost past can account for. To illustrate this important point, let us remember the system of grammatical gender in Greek or German, how irrationally a classification by sex is applied to sexless objects and thoughts, while even the use of a neuter gender fails to set the confusion straight, and sometimes even twists it with a new perversity of its own. Many a German and Frenchman wishes he could follow the example of our English forefathers who, long ago, threw overboard the whole worthless cargo of grammatical gender. But looking at gender in the ancient grammars, it must be remembered that human custom is hardly ever wilfully absurd, its unreasonableness usually arising from loss or confusion of old sense. Thus it can hardly be doubted that the misused grammatical gender in Hebrew or Greek is the remains of an older and reasonable phenomenon of language; but if so, this must have belonged to a period earlier than we can assign to the theoretical parent language of either. Lastly, the development of civilisation requires a long period of prehistoric time. Experience and history show that civilisation grew up gradually, while every age preserves recognisable traces of the ages which went before. The woodman's axe of to-day still retains much of the form of its ancestor—the stone celt in its wooden handle; the mathematician's tables keep up in their decimal rotation a record of the early ages when man's ten fingers first taught him to count; the very letters with which I wrote these lines may be followed back to the figure of birds and beasts and other objects drawn by the ancient Egyptians, at first as mere picture-writing to denote the things represented. Yet, when we learn from the monuments what ancient Egyptian life was like towards 5,000 years ago, it appears that civilisation had already come on so far that there was an elaborate system of government, an educated literary priesthood, a nation skilled in agriculture, architecture, and metal work. These ancient Egyptians, far from being near the beginning of civilisation, had, as the late Baron Bunsen held, already reached its halfway house. This eminent Egyptologist's moderate estimate of man's age on the earth at about 20,000 years has the merit of having been made on historical grounds alone, independently of geological evidence, for the proofs of the existence of man in the quaternary or mammoth period had not yet gained acceptance.

My purpose in briefly stating here the evidence of man's antiquity derived from race, language, and culture, is to insist that these arguments stand on their own ground. It is true that the geological argument from the implements in the drift-gravels and bone-caves, by leading to a general belief that man is extremely ancient on the earth, has now made it easier to anthropologists to maintain a rationally satisfactory theory of the race-types and mental development of mankind. But we should by no means give up this vantage-ground, though the ladder we climbed by should break down. Even if it could be proved that the flint implements of Abbeville or Torquay were really not so ancient as the pyramids of Egypt, this would not prevent us from still assuming, for other and sufficient reasons, a period of human life on earth extending many thousand years farther back.

It is an advantage of this state of the evidence that it to some extent gets rid of the "sensational" element in the problem of fossil man, which it leaves as merely an interesting inquiry into the earliest known relics of savage tribes. Geological criticism has not yet absolutely settled either way the claims of the Abbé Bourgeois' flints from Thénay to be of miocene date, or of Mr. Skertchly's from Brandon to be glacial. The accepted point is that the men who made the ordinary flint implements of the drift lived in the quaternary period characterised by the presence of the mammoth in our part of Europe. More than one geologist, however, has lately maintained that this quaternary period was not of extreme antiquity. The problem is at what distance from the present time the drift-gravels on the valley slopes can have been deposited by water action up to one hundred feet or so above the present flood-levels. It does not seem the prevailing view among geologists that rivers on the same small scale as those at present occupying mere ditches in the wide valley-floors could have left these deposits on the hill sides at a

time when they had not yet scooped out the valleys to within fifty or a hundred feet of their present depth. Indeed, such means are insufficient out of all proportion to the results, as a mere look down from the hill-tops into such valleys is enough to show. Geologists connect the deposit of the high drift-gravels with the subsidence and elevation of the land, and the powerful action of ice and water at the close of the Glacial age; and the term "Pluvial period" is often used to characterise this time of heavy rainfall and huge rivers. It was then that the rude stone implements of palæolithic man were imbedded in the drift-gravels with the remains of the mammoth and fossil rhinoceros, and we have to ask what events have taken place in these regions since? The earth's surface has been altered to bring the land and water to their present levels, the huge animals became extinct, the country was inhabited by the tribes whose relics belong to the neolithic or polished-stone age, and afterwards the metal-using Keltic nations possessed the land, their arrival being fixed as previous to 400 B.C., the king of the Gauls then being called by the Romans by the name *Brennus*, which is simply the Keltic word for "king"—in modern Welsh *brenin*. To take in this succession of events geologists and archaeologists generally hold that a long period is required. Yet there are some few who find room for them all in a comparatively short period. I will mention Principal Dawson, of Montreal, well known as a geologist in this Association, and who has shown his conviction of the soundness of his views by addressing them to the general public in a little volume entitled "The Story of the Earth and Man." Having examined the gravels of St. Acheul, on the Somme, where M. Boucher de Perthes found his celebrated drift implements, it appeared to Dr. Dawson that, taking into account the probabilities of a different level of the land, a wooded condition of the country and greater rainfall, and a glacial filling up of the Somme valley with clay and stones subsequently cut out by running water, the gravels could scarcely be older than the Abbeville peat, and the age of this peat he estimates as perhaps less than four thousand years. Within this period Dr. Dawson includes a comparatively rapid subsidence of the land, with a partial re-elevation, which left large areas of the lower grounds beneath the sea. This he describes as the geological deluge which separates the post-glacial period from the modern, and the earlier from the later prehistoric period of the archaeologists.

My reason for going here into these computations of Dr. Dawson's is that the date about 2,200 B.C., to which he thus assigns these great geological convulsions, is actually within historic times. In Egypt successive dynasties had been reigning for ages, and the pyramids had long been built; while in Babylonia the old Chaldean kings had been raising the temples whose ruins still remain. That is to say, we are asked to receive, as matter of geology, that stupendous geological changes were going on not far from the Mediterranean, including a final plunge of I know not how much of the earth's surface beneath the waters, and yet national life on the banks of the Nile and the Euphrates went on unbroken and apparently undisturbed through it all. To us in this section it is instructive to see how the free use of paroxysms and cataclysms makes it possible to shorten up geological time. Accustomed as we are to geology demanding periods of time which often seem to history exorbitant, the tables are now turned, and we are presented with the unusual spectacle of chronology protesting against geology for encroaching on the historical period.

In connection with the question of quaternary man, it is worth while to notice that the use of the terms "primæval" or "primitive" man, with reference to the savages of the mammoth period, seems sometimes to lead to unsound inferences. There appears no particular reason to think that the relics from the drift-beds or bone-caves represent man as he first appeared on the earth. The contents of the caves especially bear witness to a state of savage art, in some respects fairly high, and which may possibly have somewhat fallen off from an ancestral state in a more favourable climate. Indeed, the savage condition generally, though rude and more or less representing early stages of culture, never looks absolutely primitive, just as no savage language ever has the appearance of being a primitive language. What the appearance and state of our really primæval ancestors may have been seems too speculative a question, until there shall be more signs of agreement between the anthropologists, who work back by comparison of actual races of man toward a hypothetical common stock, and the zoologists, who approach the problem through the species adjoining the human. There is, however, a point relating to the problem to which attention is

due. Naturalists not unreasonably claim to find the geographical centre of man in the tropical regions of the Old World inhabited by his nearest zoological allies, the anthropomorphous apes, and there is at any rate force enough in such a view to make careful quest of human remains worth while in those districts, from Africa across to the Eastern Archipelago. Under the care of Mr. John Evans a fund has been raised for excavations in the caves of Borneo by Mr. Everett, and though the search has as yet had no striking result, money is well spent in carrying on such investigations in likely equatorial forest regions. It would be a pity that for want of enterprise a chance, however slight, should be missed of settling a question so vital to anthropology.

While the problem of primitive man thus remains obscure, a somewhat more distinct opinion may be formed on the problem of primitive civilised man. When it is asked what races of mankind first attained to civilisation, it may be answered that the earliest nations known to have had the art of writing, the great mark of civilisation as distinguished from barbarism, were the Egyptians and Babylonians, who in the remotest ages of history appear as nations advanced to the civilised stage in arts and social organisation. The question is, under what races to class them? What the ancient Egyptians were like is well known from the monuments, which show how closely much of the present fellah population, as little changed in features as in climate and life, represent their ancestors of the times of the Pharaohs. Their reddish-brown skin, and features tending toward the negroid, have led Hartmann, the latest anthropologist who has carefully studied them, to adopt the classification of them as belonging to the African rather than the Asiatic peoples, and especially to insist on their connection with the Berber type, a view which seems to have been held by Blumenbach. The contrast of the brown Egyptians with the dark-white Syro-Arabbians on their frontiers is strongly marked, and the portraits on the monuments show how distinctly the Egyptian knew himself to be of different race from the Semite. Yet there was mixture between the two races, and what is most remarkable, there is a deep-seated Semitic element in the Egyptian language, only to be accounted for by some extremely ancient and intimate connection. On the whole, the Egyptians may be a mixed race, mainly of African origin, perhaps from the southern Somaliland, whence the Egyptian tradition was that the gods came, while their African type may have since been modified by Asiatic admixture. Next, as to the early relations of Babylonia and Media, a different problem presents itself. The languages of these nations, the so-called Akkadian and the early Media, were certainly not of the same family with either the Assyrian or the Persian which afterwards prevailed in their districts. Their connection with the Tatar or Turanian family of languages, asserted twenty years ago by Oppert, has since been further maintained by Lenormant and Sayce, and seems, if not conclusively settled, at any rate to have much evidence for it, not depending merely on similarity of words, such as the term for "god," Akkadian *dingira*, being like the Tatar *tengri*, but also on the similarity of pronouns and grammatical structure by postpositions. Now language, though not a conclusive argument as to race, always proves more or less as to connection. The comparison of the Akkadian language to that of the Tatar family is at any rate *prima facie* evidence that the nations who founded the ancient civilisation of Babylonia, who invented the cuneiform writing, and who carried on the astronomical observations which made the name of Chaldean famous for all time, may have been not dark-white peoples like the Assyrians who came after them, but perhaps belonged to the yellow race of Central Asia, of whom the Chinese are the branch now most distinguished in civilisation. M. Lenormant has tried to identify among the Assyrian bas-reliefs certain figures of men whose round skulls, high cheek-bones, and low-bridged noses present a Mongoloid type contrasting with that of the Assyrians. We cannot, I think, take this as proved, but at any rate in these figures the features are not those of the aquiline Semitic type. The bronze statuette of the Chaldean king called Gudea, which I have examined with Mr. Pinches at the British Museum, is also, with its straight nose and long thin beard, as un-Assyrian as may be. The anthropological point towards which all this tends is one of great interest. We of the white race are so used to the position of leaders in civilisation, that it does not come easy to us to think we may not have been its original founders. Yet the white race, whether the dark-whites, such as Phœnicians or Hebrews, Greeks or Romans, or the fair-whites, such as Scandinavians and

Teutons, appear in history as followers and disciples of the Egyptians and Babylonians who taught the world writing, mathematics, philosophy. These Egyptians and Babylonians, so far as present evidence reaches, seem rather to have belonged to the races of brown and yellow skin than to the white race.

It may be objected that this reasoning is in several places imperfect, but it is the use of a departmental address not only to lay down proved doctrines, but to state problems tentatively as they lie open to further inquiry. This will justify my calling attention to a line of argument which, uncertain as it at present is, may perhaps lead to an interesting result. So ancient was civilisation among both Egyptians and Chaldeans, that the contest as to their priority in such matters as magical science was going on hotly in the classic ages of Greece and Rome. Looking at the literature and science, the arts and politics, of Memphis and of Ur of the Chaldees, both raised to such height of culture near 5,000 years ago, we ask, were these civilisations not connected, did not one borrow from the other? There is at present a clue which, though it may lead to nothing, is still worth trial. The hint of it lies in a remark by Dr. Birch as to one of the earliest of Egyptian monuments, the pyramid of Kochome, near Sakkara, actually dating from the first dynasty, no doubt beyond 3000 B.C., and which is built in steps like the seven-storied Babylonian temples. Two other Egyptian pyramids, those of Abu-sir, are also built in steps. Now whether there is any connection between the building of these pyramids and the Babylonian towers, does not depend on their being built in stages, but in the number of these stages being seven. As to the Babylonian towers, there is no doubt, for though Birs-Nimrud is now a ruinous heap, the classical descriptions of such temples, and the cuneiform inscriptions, put it beyond question that they had seven stages, dedicated to the seven planets. As to the Egyptian pyramids, the archaeologists Segato and Masi positively state of one step-pyramid of Abur-sir, that it had seven decreasing stages, while, on the other hand, Vyse's reconstruction of the step-pyramid of Sakkara shows there only six. Considering the ruinous state of all three step-pyramids, it will require careful measurement to settle whether they originally had seven stages or not. If they had, the correspondence cannot be set down to accident, but must be taken to prove a connection between Chaldæa and Egypt as to the worship of the seven planets, which will be among the most ancient links connecting the civilisations of the world. I hope by thus calling attention to the question, to induce some competent architect visiting Egypt to place the matter beyond doubt, one way or the other.

While speaking of the high antiquity of civilisation in Egypt, the fact calls for remark, that the use of iron as well as bronze in that country seems to go back as far as historical record reaches. Brugsch writes in his "Egypt under the Pharaohs," that Egypt throws scorn on the archaeologists' assumed successive periods of stone, bronze, and iron. The eminent historian neglects, however, to mention facts which give a different complexion to the early Egyptian use of metals, namely, that chipped flints, apparently belonging to a prehistoric Stone Age, are picked up plentifully in Egypt, while the sharp stones or stone knives used by the embalmers seem also to indicate an earlier time when these were the cutting instruments in ordinary use. Thus there are signs that the Metal Age in Egypt, as elsewhere in the world, was preceded by a Stone Age, and if so, the high antiquity of the use of metal only throws back to a still higher antiquity the use of stone. The ancient iron-working in Egypt is, however, the chief of a group of facts which are now affecting the opinions of anthropologists on the question whether the Bronze Age everywhere preceded the Iron Age. In regions where, as in Africa, iron ore occurs in such a state that it can after mere heating in the fire be forged into implements, the invention of iron-working would be more readily made than that of the composite metal bronze, which perhaps indicates a previous use of copper, afterwards improved on by an alloy of tin. Prof. Rolleston, in a recent address on the Iron, Bronze, and Stone Ages, insists with reason that soft iron may have been first in the hands of many tribes, and may have been superseded by bronze as a preferable material for tools and weapons. We moderns, used to fine and cheap steel, hardly do justice to the excellence of bronze, or gun-metal as we should now call it, in comparison with any material but steel. I well remember my own surprise at seeing in the Naples Museum that the surgeons of Herculaneum and Pompeii used instruments of bronze. It is when hard steel comes in, that weapons both of bronze and wrought iron have to yield, as when the long soft iron broad-

swords of the Gauls bent at the first blow against the pikes of Flaminius' soldiers. On the whole, Prof. Virchow's remarks in the *Transactions* of the Berlin Anthropological Society for 1876, on the question whether it may be desirable to recognise instead of three only two ages, a Stone Age and a Metal Age, seem to put the matter on a fair footing. Iron may have been known as early as bronze or even earlier, but nevertheless there have been periods in the life of nations when bronze, not iron, has been the metal in use. Thus there is nothing to interfere with the facts resting on archaeological evidence, that in such districts as Scandinavia or Switzerland a Stone Age was at some ancient time followed by a Bronze Age, and this again by an Iron Age. We may notice that the latter change is what has happened in America within a few centuries, where the Mexicans and Peruvians, found by the Spaniards living in the Bronze Age, were moved on into the Iron Age. But the question is whether we are to accept as a general principle in history the doctrine expounded in the poem of Lucretius, that men first used boughs and stones, that then the use of bronze became known, and lastly iron was discovered. As the evidence stands now, the priority of the Stone Age to the Metal Age is more firmly established than ever, but the origin of both bronze and iron is lost in antiquity, and we have no certain proof which came first.

Passing to another topic of our science, it is satisfactory to see with what activity the comparative study of laws and customs, to which Sir Henry Maine gave a new starting-point in England, is now pursued. The remarkable inquiry into the very foundations of society in the structure of the family, set afoot by Bachofen in his "Mütterrecht," and McLennan in his "Primitive Marriage," is now bringing in every year new material. Mr. L. H. Morgan, who, as an adopted Iroquois, became long ago familiar with the marriage laws and ideas of kinship of uncivilised races, so unlike those of the civilised world, has lately made, in his "Ancient Society," a bold attempt to solve the whole difficult problem of the development of social life. I will not attempt here any criticism of the views of these and other writers on a problem where the last word has certainly not been said. My object in touching the subject is to mention the curious evidence that can still be given by rude races as to their former social ties, in traditions which will be forgotten in another generation of civilised life, but may still be traced by missionaries and others who know what to seek for. Thus, such inquiry in Polynesia discloses remarkable traces of a prevalent marriage-tie which was at once polygamous and polyandrous, as where a family of brothers were married jointly to a family of sisters; and I have just noticed in a recent volume on "Native Tribes of South Australia," a mention of a similar state of things occurring there. As to the general study of customs, the work done for years past by such anthropologists as Prof. Bastian, of Berlin, is producing substantial progress. Among recent works I will mention Dr. Karl Andree's "Ethnologische Parallelen" and Mr. J. A. Farrer's "Primitive Manners." In the comparison of customs and inventions, however, the main difficulty still remains to be overcome, how to decide certainly whether they have sprung up independently alike in different lands through likeness in the human mind, or whether they have travelled from a common source. To show how difficult this often is, I may mention the latest case I have happened to meet with. The Orang Dongo, a mountain people in the Malay region, have a custom of inheritance that when a man dies the relatives each take a share of the property, and the deceased inherits one share for himself, which is burnt or buried for his ghost's use, or eaten at the funeral feast. This may strike many of my hearers as quaint enough and unlikely to recur elsewhere; but Mr. Charles Elton, who has special knowledge of our ancient legal customs, has pointed out to me that it was actually old Kentish law, thus laid down in Law-French:—"Ensement seient les chateus de gauylekendeys parties en treis apres le exeques e les dettes rendues si il y est issue mulier en vye, issi que la mort eyt la une partie, e les fitz e les filles muliers lautre partie e la femme la tierce partie."—"In like sort let the chattels of gavelkind persons be divided into three after the funeral and payment of debts, if there be lawful issue living, so that the deceased have one part, and the lawful sons and daughters the other part, and the wife the third part." The Church had indeed taken possession, for pious uses, of the dead man's share of his own property; but there is good Scandinavian evidence that the original custom before Christian times was for it to be put in his burial-mound. Thus the right of the rude Malay tribe corre-

sponds with that of ancient Europe, and the question which the evidence does not yet enable us to answer, is whether the custom was twice invented, or whether it spread east and west from a common source, perhaps in the Aryan district of Asia.

It remains for me to notice the present state of Comparative Mythology, a most interesting, but also most provoking part of Anthropology. More than twenty years ago a famous essay, by Prof. Max Müller, made widely known in England how far the myths in the classical dictionary and the story-books of our own lands might find their explanation in poetic nature-metaphors of sun and sky, cloud and storm, such as are preserved in the ancient Aryan hymns of the Veda. Of course it had been always known that the old gods and heroes were in some part personifications of nature—that Helios and Okeanos, though they walked and talked and begat sons and daughters were only the Sun and Sea in poetic guise. But the identifications of the new school went farther. The myth of Endymion became the simple nature-story of the setting Sun meeting Selene the Moon; and I well remember how, at the Royal Institution, the aged scholar, Bishop Thirlwall, grasped the stick he leant on, as if to make sure of the ground under his feet, when he heard it propounded that Erinys, the dread avenger of murder, was a personification of the Dawn discovering the deeds of darkness. Though the study of mythology has grown apace in these later years, and many of its explanations will stand the test of future criticism, I am bound to say that mythologists, always an erratic race, have of late been making wilder work than ever with both myth and real history, finding mythic suns and skies in the kings and heroes of old tradition, with dawns for love-tales, storms for wars, and sunsets for deaths, often with as much real cogency as if some mythologist a thousand years hence should explain the tragic story of Mary Queen of Scots as a nature-myth of a beauteous Dawn rising in splendour, prisoned in a dark cloud-island, and done to death in blood-red sunset. Learned treatises have of late, by such rash guessings, shaken public confidence in the more sober reasonings on which comparative mythology is founded, so that it is well to insist that there are cases where the derivation of myths from poetic metaphors is really proved beyond doubt. Such an instance is the Hindu legend of King Bali, whose austerities have alarmed the gods themselves, when Vamana, a Brahmanic Tom Thumb, begs of him as much land as he can measure in three steps; but when the boon is granted, the tiny dwarf expands gigantic into Vishnu himself, and striding with one step across the earth, with another across the air, and a third across the sky, drives the king down into the infernal regions, where he still reigns. There are various versions of the story, of which one may be read in Southey; but in the ancient Vedic hymns its origin may be found when it was not as yet a story at all, only a poetic metaphor of Vishnu, the Sun, whose often-mentioned act is his crossing the airy regions in his three strides. "Vishnu traversed (the earth), thrice he put down his foot; it was crushed under his dusty step. Three steps hence made Vishnu, unharmed preserver, upholding sacred things." Both in the savage and civilised world there are many myths which may be plainly traced to such poetic fancies before they have yet stiffened into circumstantial tales; and it is in following out these, rather than in recklessly guessing myth-origins for every tradition, that the sound work of the mythologist lies. The scholar must not treat such nature-poetry like prose, spoiling its light texture with too heavy a grasp. In the volume published by our new Folk-Lore Society, which has begun its work so well, Mr. Lang gives an instance of the sportive nature-metaphor which still lingers among popular story-tellers. It is Breton, and belongs to that wide-spread tale of which one version is naturalised in England as "Dick Whittington and his Cat." The story runs thus:—"The elder brother has the cat, while the next brother, who has a cock left him, fortunately finds his way to a land where (there being no cocks) the king has every night to send chariots and horses to bring the dawn; so that here the fortunate owner of Chanticleer has brought him to a good market. Thus we see that the Breton peasant of our day has not even yet lost the mythic sense with which his remote Aryan ancestors could behold the chariots and horses of the dawn. But myth, though largely based on such half-playful metaphor, runs through all the intermediate stages which separate poetic fancy from crude philosophy embodied in stories seriously devised as explanations of real facts. No doubt many legends of the ancient world, though not really history, are myths which have arisen by reasoning on actual events, as definite as that which, some four years ago, was terrifying the peasant mind in North

Germany, and especially in Posen. The report had spread far and wide that all Catholic children with black hair and blue eyes were to be sent out of the country, some said to Russia, while others declared that it was the King of Prussia who had been playing cards with the Sultan of Turkey, and had staked and lost 40,000 fair-haired blue-eyed children; and there were Moors travelling about in covered carts to collect them; and the schoolmasters were helping, for they were to have five dollars for every child they handed over. For a time the popular excitement was quite serious; the parents kept the children away from school and hid them, and when they appeared in the streets of the market-town the little ones clung to them with terrified looks. Dr. Schwartze, the well-known mythologist, took the pains to trace the rumour to its sources. One thing was quite plain, that its prime cause was that grave and learned body, the Anthropological Society of Berlin, who, without a thought of the commotion they were stirring up, had, in order to class the population as to race, induced the authorities to have a census made throughout the local schools, to ascertain the colour of the children's skin, hair, and eyes. Had it been only the boys, to the Government inspection of whom for military conscription the German peasants are only too well accustomed, nothing would have been thought of it; but why should the officials want to know about the little girls' hair and eyes? The whole group of stories which suddenly sprang up were myths created to answer this question; and even the details which became embodied with them could all be traced to their sources, such as the memories of German princes selling regiments of their people to pay their debts, the late political negotiations between Germany and Russia, &c. The fact that a caravan of Moors had been travelling about as a show accounted for the covered carts with which they were to fetch the children; while the schoolmasters were naturally implicated, as having drawn up the census. One schoolmaster, who evidently knew his people, assured the terrified parents that it was only the children with blue hair and green eyes that were wanted—an explanation which sent them home quite comforted. After all, there is no reason why we should not come in time to a thorough understanding of mythology. The human mind is much what it used to be, and the principles of myth-making may still be learnt from the peasants of Europe.

When, within the memory of some here present, the Science of Man was just coming into notice, it seemed as though the study of races, customs, traditions, were a limited though interesting task, which might, after a few years, come so near the end of its materials as no longer to have much new to offer. Its real course has been far otherwise. Twenty years ago it was no difficult task to follow it step by step; but now even the yearly list of new anthropological literature is enough to form a pamphlet, and each capital of Europe has its anthropological society in full work. So far from any look of finality in anthropological investigations, each new line of argument but opens the way to others behind, while these lines tend as plainly as in the sciences of stricter weight and measure, toward the meeting-ground of all sciences in the unity of nature.

SECTION G

MECHANICAL SCIENCE

OPENING ADDRESS BY J. ROBINSON, PRES. INST. MECH. ENG., PRESIDENT OF THE SECTION

On the Development of the Use of Steel during the Last Forty Years, considered in its Mechanical and Economic Aspects

MUCH has been written by poets and others of a succession of the Ages of the human race in comparing their degradation with the various kinds of metal, considered metaphorically—thus we have the golden age, the silver age, the age of brass, and the age of iron.

Our own time may very appropriately and literally be described as a branch of the latter age, and be named the age of steel.

In the metropolis of the steel manufacture it would seem fitting that the Mechanical Section of this great scientific association should direct its attention to this wonderful metal, the uses of which are daily becoming more numerous and important.

But it may be said, on the other hand, that as the use of this material is perpetually growing more common, so are discussions as to its manufacture, composition, and characteristics, becoming almost wearisome from their frequency.

Notwithstanding an appearance of truth in this objection to our occupying more time in referring to the subject, I would venture to entertain the hope that a treatment of the question in its mechanical and economic aspects may prove not uninteresting to this meeting.

At the time when railway extension was becoming general, about forty years ago, the use of steel in this country was confined mainly to tools for mechanical purposes, including files and other articles, springs for vehicles, weapons of various sorts, and implements for agricultural and domestic uses; and it is proposed to measure the scientific and mechanical energy brought to bear upon the manufacture and improvement of this metal by the increase in the number of purposes to which it is applied, and the diminished price at which it can be obtained, as compared with the price at the time of its introduction for constructive works. There are, however, several important exceptions to this method of appreciation to which reference will hereafter be made.

We will take, then, the simplest form in the preceding list, viz., *tool steel*, the price of which for ordinary purposes varied from 50s. to 56s. per cwt. at the period I have named; and we shall find that the development of the manufacture of steel in general has but little affected this particular material, which is still produced in much the same fashion, i.e., by the use of carefully selected Swedish iron, carburised by exposure in ovens to the heat of burning charcoal, and then recast from crucibles and hammered down to the required size. The result of a somewhat stationary condition of manufacture has been the maintenance of prices, at the same, or about the same, level up to the present time.

A superior quality of tool steel has been produced by the adoption of a process invented by Mr. R. Musket, in which titanium is introduced in the manufacture, and which dates back to the year 1838-39. This steel is of great endurance when applied to the working of steel and iron of considerable hardness, and its higher price of 140s. per cwt. is quite justified by the excellent results obtained from its use, and other steels of similar fine quality are produced by several manufacturers, who make specialities of them.

Some twenty-seven or twenty-eight years ago, Krupp, of Essen, gave an enormous impulse to the application of steel, by his method of producing much larger masses of crucible steel than had previously been possible. He at that time accomplished the casting of an ingot of "crucible" steel of 50 cwt., a weight then considered incredible, and this was followed up by the production of weldless cast steel tyres in 1852, which led to the very rapid development in the use of his steel for railway tyres, cranked axles for locomotive and other engines, straight axles and shafts, and parts of machines in general.

It is most interesting to consider the prices of such of these objects as have up to this time maintained similar forms, with the object of ascertaining by the selling price, the progress in the scientific and mechanical appliances used for the production of the materials just referred to.

At the time of their coming into use, about twenty-five years ago, the price of cast steel tyres was 120s. per cwt.; it is now from 18s. to 25s. per cwt. The price of forged steel cranked axles was, when first introduced, 15*l.* per cwt.; it is now from 65s. to 70s. per cwt.

The price of straight axles and shafts was from 40s. to 50s. per cwt.; it is now from 19s. 6*d.* to 23s. per cwt.

Now to what do we owe this enormous reduction of price and consequent more frequent and more economic application? The answer must be that, following the initiation of Krupp, our English engineers and men of science set themselves to work to discover and apply new processes for the production and manufacture of this most wonderful metal; and I venture to say that in the whole history of metallurgy, from the time of Tubal Cain downwards, there has been no such progress in invention and manufacture as has been realised by the aid of such men as Mushet, Krupp, Bessemer, Siemens, Whitworth, Martin, Vickers, Bell, Bauschinger, Styffe, and many others within the period comprised in this retrospect; and our national predilections will perhaps lead us to the opinion that our own country may fairly appropriate a large share of merit for the results achieved.

Another of the uses of steel to which attention may be given is that of the production of cannon of large size.

Efforts had been made by some of our enterprising workers in metal to produce large guns of solid wrought iron; but the

processes of heating and hammering were attended with so much difficulty that the attempt was given up. Here again Krupp stepped in, and succeeded, thirty-two years ago, in manufacturing cannon of cast steel, which unhappily have become ordinary commodities with those nationalities who could afford such expensive weapons. Since that time Krupp has produced about 2,000 guns, the heaviest being, when finished, 72 tons (16 inch).

Sir William Armstrong and Sir Joseph Whitworth soon came into the field with guns of their own invention. The former, by adopting the system of iron coils applied externally to a central cylinder; and the latter, by shrinking cylindrical hoops on to a central cylinder made of cast steel.

In the adaptation of the steel manufacture of the cast or crucible steel period to the production of every object demanded by the march of engineering and mechanical science, I need not mention the names of individuals and firms in this town who have shown themselves equal to the task; but I will venture to say that their success has been such as to raise the town of Sheffield to the very pinnacle of fame as producing steel of any, even the highest quality demanded in the markets of the world.

I must now turn to a name honoured everywhere for the benefits and renown he has brought to his country by his inventions and appliances, developed during the last twenty-four or twenty-five years, in the manufacture of a steel which can be cheaply produced and readily adapted to the requirements of the purchaser. I am sure the audience will in their minds anticipate the record of the name of Bessemer—a name which will be handed down to posterity in connection with the manufacture of steel as long as that manufacture exists.

Another name which will most deservedly figure in the history of the development of the steel manufacture is one, like that of Bessemer, which has been known not only in that development, but in connection with many other discoveries in physical science—I mean that of Siemens, who, like his compeer, has not only invented processes, but has personally carried them out into practical application. An expression let fall by the latter as President of the Iron and Steel Institute at its meeting last year in Paris, exhibits very strikingly the absence of any other feeling on the part of these two great men save that of the most friendly rivalry.

Speaking of a comparison between the results of steel manufactured by the Bessemer blowing process and the Siemens-Martin open-hearth process, Dr. Siemens said, "He did not see how the result could be the same. It might be better in the Bessemer process than in the open hearth for aught he knew, but it could not be the same;" and it seems to augur well for the advancement of science in our day that so little of a contrary spirit is exhibited in the discussions which ensue from time to time upon any improved process either chemical or mechanical, having for its object the production of a better material at a lower first cost. The name of Robert Mushet may very properly be introduced here as one of our early inventors of the improved processes for the manufacture of steel, and it is gratifying to find that other countries besides England have learnt to appreciate the results obtained by him during so many years of scientific and experimental research.

It is needless that I should do more in an assembly like that before me than refer, in the simplest terms, to the differences in the processes of manufacture connected with these names.

In that of Bessemer, pig-iron of a selected quality is charged into what is technically called a "converter," a large cast-iron vessel into which air can be blown at considerable velocity by suitable blowing machinery. This goes on until the iron is thoroughly oxidised, and the impurities contained in the metal are driven off. When this happens the blowing ceases, and a certain proportion of Spiegeleisen or of ferro-manganese is added to the charge so as to give the required amount of carbon. Blowing recommences, this time only to effect complete mixture of the materials, and then the casting of the ingots takes place of a quality corresponding to the metal selected for the mixtures. A mild steel—or, as it has been called, a pure iron—is the resultant, and it is capable of being worked, welded, and hammered very much as in the case of the purest wrought irons; but it possesses generally a much higher tensile resistance and a greater ductility.

In the Siemens-Martin, or open-hearth process, a similar charge of pig-iron of the desired quality—probably hæmatite pig—is put into the bed of a reverberatory furnace of the regenerative system, and the necessary oxidation is produced by

adding to the molten mass iron ores, or oxides of iron in proportions ascertained by experience, after which re-carbonisation is obtained by the addition of ferro-manganese or Spiegeleisen as in the Bessemer process.

These processes have been the great factors in that reduction in the cost price, and therefore in the extension of the use of such objects as steel tyres, axles, shafts, rails, &c., to which I have already referred, and which is so striking an instance of the results which our men of science can accomplish by their physical and experimental researches into the means of supplying the wants of our work-a-day world.

I will now draw attention to another product of the steel manufacture which is of immense importance, and which could not have been obtained for ordinary purposes but for the facilities of manufacture arising out of the inventions I have just alluded to—I mean that of steel castings, *i.e.* castings obtained from the crucible, precisely in the form in which they are to be used in the construction of machinery, just as is the case in ordinary cast iron run from the cupola furnace. This production of castings for engineering purposes is gaining an enormous and rapid development; and when it is considered that in this metal we obtain castings of a strength at least three to four times that of the strongest iron castings, the importance of this experimental discovery can scarcely be over-rated.

Nor must I pass over the application of these processes to the production of boiler plates, bridge girder plates, and ship plates, in which, as a result of the greater tensile resistance of such plates (reaching for ordinary uses a figure of about twenty-eight to thirty-four tons to the square inch), the engineer is not only enabled to lighten his structure, but to expect from it greater durability—an expectation not diminished by its greater capability of resisting corrosion, especially where care is taken to exclude manganese from the mixture of the metals employed.

For specific purposes, and where price is not so much an element of consideration as great tensile or percussive resistance, a more costly mode of manufacture has been adopted by Sir Joseph Whitworth, whose attention was probably drawn to the necessity for obtaining such a metal, during the construction of cannon and torpedoes, but which has now been extended to objects of a very varied character. The method of manufacture, which has been in use upwards of ten years, is by casting ingots under very heavy hydraulic pressures, from very carefully selected materials, the result being the production of a metal of enormous tensile resistance, reaching, in some instances, the high figure of 100 tons per square inch, while at the same time the bubbles and air vesicles, which sometimes appear in metal produced in the ordinary methods, are entirely or almost entirely got rid of, and the consequent striations and imperfections of internal structure and external surface disappear.

It is hoped that ere long we shall be able to procure in this way cylindrical boiler plates rolled solid from the ingot, much after the fashion in which weldless steel tyres are now obtained, and that the weakening of these plates by the existing necessity for forming horizontal riveted joints may thus be avoided.

It is desirable before closing this, I fear, already somewhat long address, to call attention to the most recent development of the steel manufacture as exhibited in the processes of Messrs. Snellus, Gilchrist, and Thomas, by which iron containing a considerable proportion of, say, 1.44 per cent. of phosphorus, may, in the course of its manufacture into either Bessemer or Siemens-Martin steel, have this deleterious matter entirely removed, or reduced to an inconsiderable proportion.

The method of carrying out this operation was exceedingly well described at the recent meeting of the Iron and Steel Institute in London, and it was shown that where such irons were melted in vessels lined with a slag having twenty per cent. of silica and thirty per cent. of lime and magnesia, the phosphorus was gradually and effectually absorbed by this lining, and a steel of good quality, comparatively free from phosphorus and silica, was produced.

The result to the community will naturally be that, as henceforth a much more extended area of our iron fields both at home and abroad will become available for the production of steel, the use of that metal will be still further extended and its price reduced mainly by means of the methodical researches of our scientific metallurgists, and entirely independently of those accidental combinations which have in less scientific days led to the adoption of new and improved methods in the production of metals required by the progress of mechanical and economic science.

ON RADIANT MATTER¹

TO throw light on the title of this lecture I must go back more than sixty years—to 1816. Faraday, then a mere student and ardent experimentalist, was twenty-four years old, and at this early period of his career he delivered a series of lectures on the general properties of matter, and one of them bore the remarkable title, "On Radiant Matter." The great philosopher's notes of this lecture are to be found in Dr. Bence Jones's "Life and Letters of Faraday," and I will here quote a passage in which he first employs the expression *Radiant Matter*:—

"If we conceive a change as far beyond vaporisation as that is above fluidity, and then take into account also the proportional increased extent of alteration as the changes rise, we shall perhaps, if we can form any conception at all, not fall far short of radiant matter; and as in the last conversion many qualities were lost, so here also many more would disappear."

Faraday was evidently engrossed with this far-reaching speculation, for three years later—in 1819—we find him bringing fresh evidence and argument to strengthen his startling hypothesis. His notes are now more extended, and they show that in the intervening three years he had thought much and deeply on this higher form of matter. He first points out that matter may be classed into four states—solid, liquid, gaseous, and radiant—these modifications depending upon differences in their several essential properties. He admits that the existence of radiant matter is as yet unproved, and then proceeds, in a series of ingenious analogical arguments, to show the probability of its existence.²

If, in the beginning of this century, we had asked, What is a gas? the answer then would have been that it is matter, expanded and rarefied to such an extent as to be impalpable, save when set in violent motion; invisible, incapable of assuming or of being reduced into any definite form like solids, or of forming drops like liquids; always ready to expand where no resistance is offered, and to contract on being subjected to pressure. Sixty years ago such were the chief attributes assigned to gases. Modern research, however, has greatly enlarged and modified our views on the constitution of these elastic fluids. Gases are now considered to be composed of an almost infinite number of small particles or molecules, which are constantly moving in every direction with velocities of all conceivable magnitudes. As these molecules are exceedingly numerous, it follows that no molecule can move far in any direction without coming in contact with some other molecule. But if we exhaust the air or gas contained in a closed vessel, the number of molecules becomes diminished, and the distance through which any one of them can move without coming in contact with another is increased, the length of the mean free path being inversely proportional to the number of molecules present. The further this process is carried the longer becomes the average distance a molecule can travel before entering into collision; or, in other words, the longer its mean free path the more the physical properties of the gas or air are modified. Thus, at a certain point, the phenomena of the radiometer become possible, and on pushing the rarefaction still further, *i.e.*, decreasing the number of

¹ A lecture delivered to the British Association for the Advancement of Science, at Sheffield, Friday, August 22, 1879, by William Crookes, F.R.S.
² "I may now notice a curious progression in physical properties accompanying changes of form, and which is perhaps sufficient to induce, in the inventive and sanguine philosopher, a considerable degree of belief in the association of the radiant form with the others in the set of changes I have mentioned."

"As we ascend from the solid to the fluid and gaseous states, physical properties diminish in number and variety, each state losing some of those which belonged to the preceding state. When solids are converted into fluids, all the varieties of hardness and softness are necessarily lost. Crystalline and other shapes are destroyed. Opacity and colour frequently give way to a colourless transparency, and a general mobility of particles is conferred."

"Passing onward to the gaseous state, still more of the evident characters of bodies are annihilated. The immense differences in their weight almost disappear; the remains of difference in colour that were left are lost. Transparency becomes universal, and they are all elastic. They now form but one set of substances, and the varieties of density, hardness, opacity, colour, elasticity, and form, which render the number of solids and fluids almost infinite, are now supplied by a few slight variations in weight, and some unimportant shades of colour."

"To those, therefore, who admit the radiant form of matter, no difficulty exists in the simplicity of the properties it possesses, but rather an argument in their favour. These persons show you a gradual resignation of properties in the matter we can appreciate as the matter ascends in the scale of forms, and they would be surprised if that effect were to cease at the gaseous state. They point out the greater exertions which nature makes at each step of the change, and think that, consistently, it ought to be greatest in the passage from the gaseous to the radiant form."—*Life and Letters of Faraday*, vol. i. p. 308.

molecules in a given space and lengthening their mean free path, the experimental results are obtainable to which I am now about to call your attention. So distinct are these phenomena from anything which occurs in air or gas at the ordinary tension, that we are led to assume that we are here brought face to face with matter in a fourth state or condition, a condition as far removed from the state of gas as a gas is from a liquid.

Mean Free Path. Radiant Matter

I have long believed that a well-known appearance observed in vacuum tubes is closely related to the phenomena of the mean free path of the molecules. When the negative pole is examined while the discharge from an induction-coil is passing through an exhausted tube, a dark space is seen to surround it. This dark space is found to increase and diminish as the vacuum is varied, in the same way that the mean free path of the molecules lengthens and contracts. As the one is perceived by the mind's eye to get greater, so the other is seen by the bodily eye to increase in size; and if the vacuum is insufficient to permit much play of the molecules before they enter into collision, the passage of electricity shows that the "dark space" has shrunk to small dimensions. We naturally infer that the dark space is the mean free path of the molecules of the residual gas, an inference confirmed by experiment.

I will endeavour to render this "dark space" visible to all present. Here is a tube (Fig. 1) having a pole in the centre in

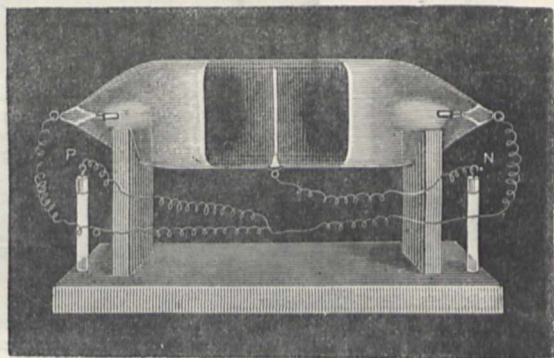


FIG. 1.

the form of a metal disk, and other poles at each end. The centre pole is made negative, and the two end poles connected together are made the positive terminal. The dark space will be in the centre. When the exhaustion is not very great the dark space extends only a little on each side of the negative pole in the centre. When the exhaustion is good, as in the tube before you, and I turn on the coil, the dark space is seen to extend for about an inch on each side of the pole.

Here, then, we see the induction spark actually illuminating the lines of molecular pressure caused by the excitement of the negative pole. The thickness of this dark space is the measure of the mean free path between successive collisions of the molecules of the residual gas. The extra velocity with which the negatively electrified molecules rebound from the excited pole, keeps back the more slowly moving molecules which are advancing towards that pole. A conflict occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the discharge.

Therefore the residual gas—or, as I prefer to call it, the gaseous residue—within the dark space, is in an entirely different state to that of the residual gas in vessels at a lower degree of exhaustion. To quote the words of our last year's President, in his address at Dublin:—

"In the exhausted column we have a vehicle for electricity not constant like an ordinary conductor, but itself modified by the passage of the discharge, and perhaps subject to laws differing materially from those which it obeys at atmospheric pressure."

In the vessels with the lower degree of exhaustion, the length of the mean free path of the molecules is exceedingly small as compared with the dimensions of the bulb, and the properties belonging to the ordinary gaseous state of matter, depending upon constant collisions, can be observed. But in the phenomena now about to be examined, so high is the exhaustion carried that the dark space around the negative pole has widened out till it entirely fills the tube. By great rarefaction the mean free path

has become so long that the hits in a given time in comparison to the misses may be disregarded, and the average molecule is now allowed to obey its own motions or laws without interference. The mean free path, in fact, is comparable to the dimensions of the vessel, and we have no longer to deal with a *continuous* portion of matter, as would be the case were the tubes less highly exhausted, but we must here contemplate the molecules *individually*. In these highly exhausted vessels the molecules of the gaseous residue are able to dart across the tube with comparatively few collisions, and radiating from the pole with enormous velocity, they assume properties so novel and so characteristic as to entirely justify the application of the term borrowed from Faraday, that of *Radiant Matter*.

Radiant Matter exerts powerful Phosphorogenic Action where it strikes

I have mentioned that the radiant matter within the dark space excites luminosity where its velocity is arrested by residual gas outside the dark space. But if no residual gas is left, the molecules will have their velocity arrested by the sides of the glass; and here we come to the first and one of the most noteworthy properties of radiant matter discharged from the negative pole—its power of exciting phosphorescence when it strikes

against solid matter. The number of bodies which respond luminously to this molecular bombardment is very great, and the resulting colours are of every variety. Glass, for instance, is highly phosphorescent when exposed to a stream of radiant matter. Here (Fig. 2) are three bulbs composed of different glass: one is uranium glass (*a*), which phosphoresces of a dark green colour; another is English glass (*b*), which phosphoresces of a blue colour; and the third (*c*) is soft German glass—which phosphoresces of a bright apple-green.

My earlier experiments were almost entirely carried on by the aid of the phosphorescence which glass takes up when it is under the influence of the radiant discharge; but many other substances possess this phosphorescent power in a still higher degree than glass. For instance, here is some of the luminous sulphide of calcium prepared according to M. Ed. Becquerel's description. When the sulphide is exposed to light—even candle-light—it phosphoresces for hours with a bluish-white colour. It is, however, much more strongly phosphorescent to the molecular discharge in a good vacuum, as you will see when I pass the discharge through this tube.

Other substances besides English, German, and uranium glass, and Becquerel's luminous sulphides, are also phosphorescent.

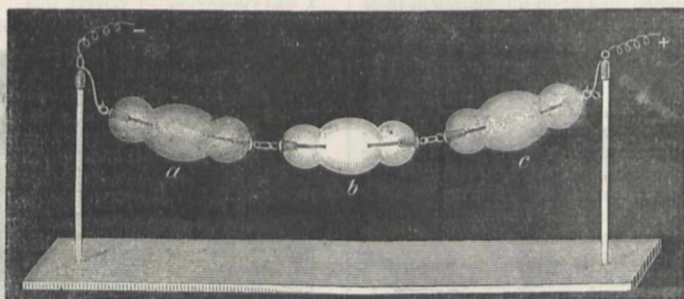


FIG. 2.

The rare mineral phenakite (aluminate of glucinum) phosphoresces blue; the mineral spodumene (a silicate of aluminium and lithium) phosphoresces a rich golden yellow; the emerald gives out a crimson light. But without exception, the diamond is the most sensitive substance I have yet met for ready and brilliant phosphorescence. Here is a very curious fluorescent diamond,

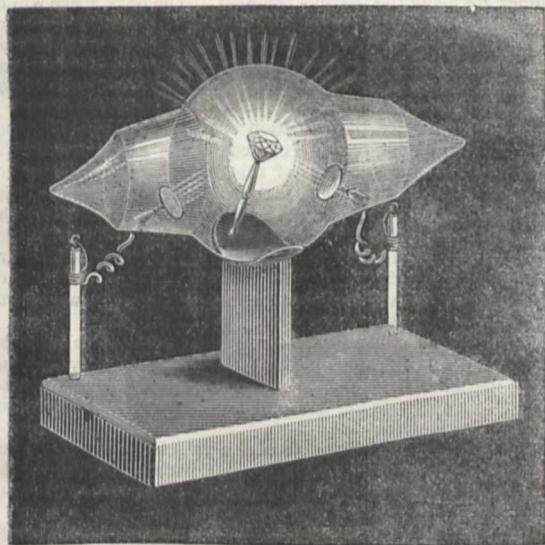


FIG. 3.

green by daylight, colourless by candle-light. It is mounted in the centre of an exhausted bulb (Fig. 3), and the molecular discharge will be directed on it from below upwards. On darkening the room you see the diamond shines with as much light as a candle, phosphorescing of a bright green.

Next to the diamond the ruby is one of the most remarkable stones for phosphorescing. In this tube (Fig. 4) is a fine collection of ruby pebbles. As soon as the induction-spark is turned on you will see these rubies shining with a brilliant rich red tone, as if they were glowing hot. It scarcely matters what colour the ruby is, to begin with. In this tube of natural rubies there are stones of all colours—the deep red and also the pale pink ruby. There are some so pale as to be almost colourless, and some of the highly-prized tint of pigeon's blood; but under the impact of radiant matter they all phosphoresce with about the same colour.

Now the ruby is nothing but crystallised alumina with a little

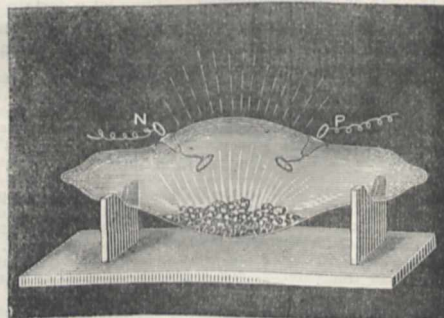


FIG. 4.

colouring-matter. In a paper by Ed. Becquerel,¹ published twenty years ago, he describes the appearance of alumina as glowing with a rich red colour in the phosphroscope. Here is some precipitated alumina prepared in the most careful manner. It has been heated to whiteness, and you see it also glows under the molecular discharge with the same rich red colour.

The spectrum of the red light emitted by these varieties of alumina is the same as described by Becquerel twenty years ago. There is one intense red line, a little below the fixed line B in

¹ *Annales de Chimie et de Physique*, 3rd series, vol. lviii, p. 59, 1859.]

the spectrum, having a wave-length of about 6895. There is a continuous spectrum beginning at about B, and a few fainter lines beyond it, but they are so faint in comparison with this red line that they may be neglected. This line is easily seen by examining with a small pocket spectroscope the light reflected from a good ruby.

There is one particular degree of exhaustion more favourable than any other for the development of the properties of radiant matter which are now under examination. Roughly speaking, it may be put at the millionth of an atmosphere.¹ At this degree of exhaustion the phosphorescence is very strong, and after that it begins to diminish until the spark refuses to pass.²

I have here a tube (Fig. 5) which will serve to illustrate the

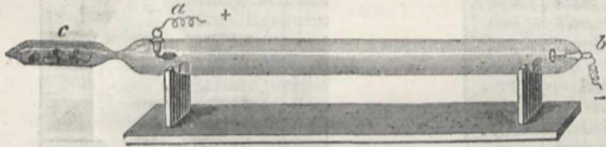


FIG. 5.

dependence of the phosphorescence or the glass on the degree of exhaustion. The two poles are at *a* and *b*, and at the end (*c*) is a small supplementary tube, connected with the other by a narrow aperture, and containing solid caustic potash. The tube has been exhausted to a very high point, and the potash heated so as to drive off moisture and injure the vacuum. Exhaustion has then been recommenced, and the alternate heating and exhaustion repeated until the tube has been brought to the state in which it now appears before you. When the induction-spark is first turned on nothing is visible—the vacuum is so high that the tube is non-conducting. I now warm the potash slightly, and liberate a trace of aqueous vapour. Instantly conduction commences, and the green phosphorescence flashes out along the length of the tube. I continue the heat, so as to drive off more gas from the potash. The green gets fainter, and now a wave of cloudy luminosity sweeps over the tube, and stratifications appear, which rapidly get narrower, until the spark passes along the tube in the form of a narrow purple line. I take the lamp away, and allow the potash to cool; as it cools, the aqueous vapour, which the heat had driven off, is re-absorbed. The purple line broadens out, and breaks up into fine stratifications; these get wider, and travel towards the potash tube. Now a wave of green light appears on the glass at the other end, sweeping on and driving the last pale stratification into the potash;

1	1'0 millionth of an atmosphere	=	0'00076 millim.
	1315'789 millionths of an atmosphere	=	1'0 millim.
	1,000,000 "	=	760'0 millions.
	" "	=	1 atmosphere.

¹ Nearly 100 years ago Mr. Wm. Morgan communicated to the Royal Society a paper entitled "Electrical Experiments made to ascertain the Non-conducting Power of a Perfect Vacuum, &c." The following extracts from this paper, which was published in the *Phil. Trans.* for 1785 (vol. lxxv. p. 272), will be read with interest:—

"A mercurial gage about 15 inches long, carefully and accurately boiled till every particle of air was expelled from the inside, was coated with tin-foil 5 inches down from its sealed end, and being inverted into mercury through a perforation in the brass cap which covered the mouth of the cistern; the whole was cemented together, and the air was exhausted from the inside of the cistern through a valve in the brass cap, which, producing a perfect vacuum in the gage, formed an instrument peculiarly well adapted for experiments of this kind. Things being thus adjusted (a small wire having been previously fixed on the inside of the cistern to form a communication between the brass cap and the mercury, into which the gage was inverted) the coated end was applied to the conductor of an electrical machine, and notwithstanding every effort, neither the smallest ray of light, nor the slightest charge, could ever be procured in this exhausted gage.

"If the mercury in the gage be imperfectly boiled, the experiment will not succeed; but the colour of the electric light, which, in air rarefied by an exhauster, is always violet or purple, appears in this case of a beautiful green, and, what is very curious, the degree of the air's rarefaction may be nearly determined by this means; for I have known instances, during the course of these experiments, where a small particle of air, having found its way into the tube, the electric light became visible, and, as usual, of a green colour; but the charge being often repeated, the gage has at length cracked at its sealed end, and in consequence the external air, by being admitted into the inside, has gradually produced a change in the electric light from green to blue, from blue to indigo, and so on to violet and purple, till the medium has at length become so dense as no longer to be a conductor of electricity. I think there can be little doubt, from the above experiments, of the non-conducting power of a perfect vacuum."

"This seems to prove that there is a limit even in the rarefaction of air, which sets bounds to its conducting power; or, in other words, that the particles of air may be so far separated from each other as no longer to be able to transmit the electric fluid; and if they are brought within a certain distance of each other their conducting power begins, and continually increases till their approach also arrives at its limit."

and now the tube glows over its whole length with the green phosphorescence. I might keep it before you, and show the green growing fainter and the vacuum becoming non-conducting, but I should detain you too long, as time is required for the absorption of the last traces of vapour by the potash, and I must pass on to the next subject.

Radiant Matter proceeds in straight Lines

The radiant matter whose impact on the glass causes an evolution of light, absolutely refuses to turn a corner. Here is a V-shaped tube (Fig. 6), a pole being at each extremity. The pole at the right side (*a*) being negative, you see that the whole of the right arm is flooded with green light, but at the bottom it stops sharply and will not turn the corner to get into the left side. When I reverse the current and make the left pole negative, the green changes to the left side, always following the negative pole and leaving the positive side with scarcely any luminosity.

In the ordinary phenomena exhibited by vacuum tubes—phenomena with which we are all familiar—it is customary, in order to bring out the striking contrasts of colour, to bend the tubes into very elaborate designs. The luminosity caused by the phosphorescence of the residual gas follows all the convolutions into which skilful glass-blowers can manage to twist the glass. The

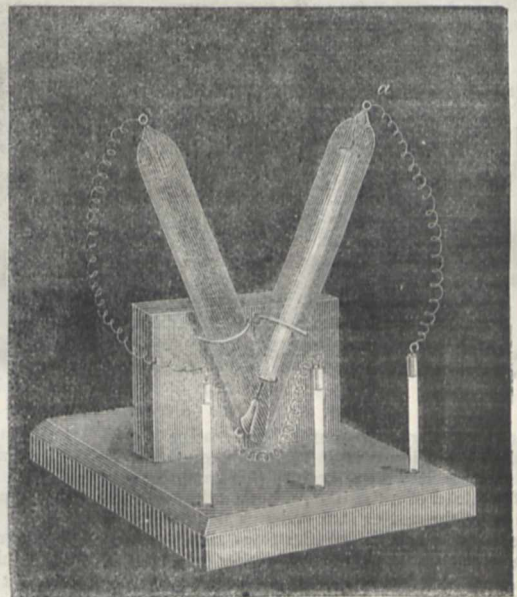


FIG. 6.

negative pole being at one end and the positive pole at the other, the luminous phenomena seem to depend more on the positive than on the negative at the ordinary exhaustion hitherto used to get the best phenomena of vacuum tubes. But at a very high exhaustion the phenomena noticed in ordinary vacuum tubes when the induction spark passes through them—an appearance of cloudy luminosity and of stratifications—disappear entirely. No cloud or fog whatever is seen in the body of the tube, and with such a vacuum as I am working with in these experiments, the only light observed is that from the phosphorescent surface of the glass. I have here two bulbs (Fig. 7), alike in shape and position of poles, the only difference being that one is at an exhaustion equal to a few millimetres of mercury—such a moderate exhaustion as will give the ordinary luminous phenomena—whilst the other is exhausted to about the millionth of an atmosphere. I will first connect the moderately exhausted bulb (*A*) with the induction-coil, and retaining the pole at one side (*a*) always negative, I will put the positive wire successively to the other poles with which the bulb is furnished. You see that as I change the position of the positive pole, the line of violet light joining the two poles changes, the electric current always choosing the shortest path between the two poles, and moving about the bulb as I alter the position of the wires.

This, then, is the kind of phenomenon we get in ordinary exhaustions. I will now try the same experiment with a bulb (*B*)

that is very highly exhausted, and as before, will make the side pole (*a'*) the negative, the top pole (*b*) being positive. Notice how widely different is the appearance from that shown by the last bulb. The negative pole is in the form of a shallow cup. The molecular rays from the cup cross in the centre of the bulb, and thence diverging fall on the opposite side and produce a circular patch of green phosphorescent light. As I turn the bulb round you will all be able to see the green patch on the glass. Now observe, I remove the positive wire from the top,

and connect it with the side pole (*c*). The green patch from the divergent negative focus is there still. I now make the lowest pole (*d*) positive, and the green patch remains where it was at first, unchanged in position or intensity.

We have here another property of radiant matter. In the low vacuum the position of the positive pole is of every importance, whilst in a high vacuum the position of the positive pole scarcely matters at all; the phenomena seem to depend entirely on the negative pole. If the negative pole points in the direction of the

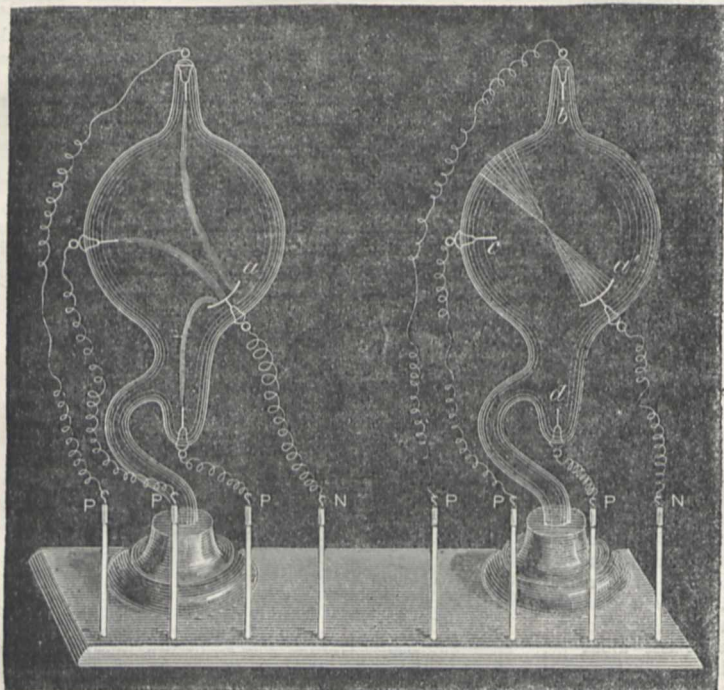


FIG. 7.

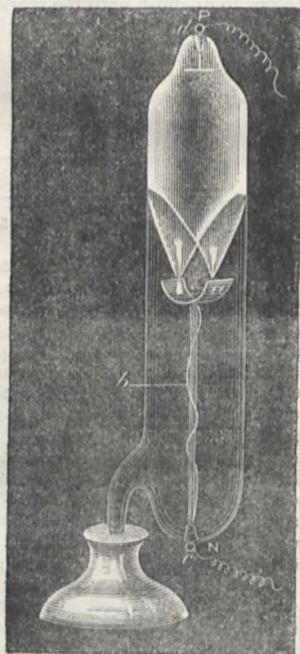


FIG. 8.

positive, all very well, but if the negative pole is entirely in the opposite direction it is of little consequence: the radiant matter darts all the same in a straight line from the negative.

If, instead of a flat disk, a hemi-cylinder is used for the negative pole, the matter still radiates normal to its surface. The tube before you (Fig. 8) illustrates this property. It contains, as a negative pole, a hemi-cylinder (*a*) of polished aluminium. This is connected with a fine copper wire, *b*, ending at the platinum terminal, *c*. At the upper end of the tube is another terminal, *d*. The induction-coil is connected so that the hemi-cylinder is negative and the upper pole positive, and when exhausted to a sufficient extent the projection of the molecular rays to a focus is very beautifully shown. The rays of matter being driven from the hemi-cylinder in a direction normal to its surface, come to a focus and then diverge, tracing their path in brilliant green phosphorescence on the surface of the glass.

Instead of receiving the molecular rays on the glass, I will show you another tube in which the focus falls on a phosphorescent screen. See how brilliantly the lines of discharge shine out, and how intensely the focal point is illuminated, lighting up the table.

Radiant Matter when intercepted by Solid Matter casts a Shadow

Radiant matter comes from the pole in straight lines, and does not merely permeate all parts of the tube and fill it with light, as would be the case were the exhaustion less good. Where there is nothing in the way the rays strike the screen and produce phosphorescence, and where solid matter intervenes they are obstructed by it, and a shadow is thrown on the screen. In this pear-shaped bulb (Fig. 9) the negative pole (*a*) is at the pointed end. In the middle is a cross (*b*) cut out of sheet aluminium, so that the rays from the negative pole projected along the tube will be partly intercepted by the aluminium cross, and will project an image of it on the hemispherical end of the tube which is phosphorescent. I turn on the coil, and you will all see the black

shadow of the cross on the luminous end of the bulb (*c, d*). Now, the radiant matter from the negative pole has been passing by the side of the aluminium cross to produce the shadow; the glass has been hammered and bombarded till it is appreciably warm, and at the same time another effect has been produced on the glass—its sensibility has been deadened. The glass has got tired, if I may use the expression, by the enforced phosphorescence. A change has been produced by this molecular bom-

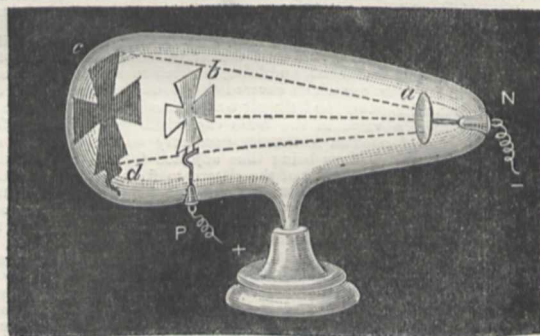


FIG. 9.

bardment which will prevent the glass from responding easily to additional excitement; but the part that the shadow has fallen on is not tired—it has not been phosphorescing at all and is perfectly fresh; therefore if I throw down this cross—I can easily do so by giving the apparatus a slight jerk, for it has been most ingeniously constructed with a hinge by Mr. Gimmingham—and so allow the rays from the negative pole to fall uninterruptedly on to the end of the bulb, you will suddenly see the black cross

(*c*, *d*, Fig. 10) change to a luminous one (*e*, *f*), because the background is now only capable of faintly phosphorescing, whilst the part which had the black shadow on it retains its full phosphorescent power. The stencilled image of the luminous cross unfortunately soon dies out. After a period of rest the glass partly recovers its power of phosphorescing, but it is never so good as it was at first.

Here, therefore, is another important property of radiant matter. It is projected with great velocity from the negative pole, and not only strikes the glass in such a way as to cause it to vibrate and become temporarily luminous while the discharge is going on, but the molecules hammer away with sufficient energy to produce a permanent impression upon the glass.

(To be continued.)

NOTES

IN accordance with the resolution come to at the recent International Congress of Meteorology, the International Committee have issued circulars for a special Conference at the Deutsche Seewarte at Hamburg, on October 1, to consider the scheme of Count Wilczek and Lieut. Weyprecht for the establishment of circumpolar observing stations. The Conference will consider specially the following points:—1. The number of observatories and the most convenient places at which to establish them. The decision will depend on the number of co-operating states and the sums which they are willing to devote to this purpose. Count Wilczek and Lieut. Weyprecht have proposed the following places:—In the Northern Hemisphere: north coasts of Spitzbergen and of Novaya Zemlya, the neighbourhood of the North Cape, the mouth of the Lena, New Siberia, Point Barrow, on the north-east of Behring Strait, west coast of Greenland, east coast of Greenland, about 75° N. lat. In the Southern Hemisphere: the neighbourhood of Cape Horn, Kerguelen or Macdonald Islands, one of the groups south of the Auckland Islands. 2. There will be considered the exact epoch of the observations and their maximum duration. 3. Uniform instruction for observations, which will have to fix especially: (*a*) The minimum of elements to be observed at each station, both for meteorological phenomena and for those of terrestrial magnetism, as well as for other phenomena of terrestrial physics connected with them. (*b*) The minimum number of daily observations for the different elements. (*c*) The first meridian which will serve as basis for simultaneous observations. (*d*) Methods of observation for the different elements and methods of reduction. (*e*) Instruments of observation and their arrangement, as far as they may influence the comparability of the results.

AT a recent meeting of the Committee of the Iron and Steel Institute in Liverpool it was arranged that this year's meeting should be held in Liverpool on September 24, 25, and 26. The use of St. George's Hall has been granted by the Corporation, and numerous places for inspection and excursion have been partly arranged for, including Messrs. Blundell's collieries, near Wigan, and the Tubular Bridge at Menai Straits. In addition to papers on the manufacture and application of steel and iron, papers on subjects of work more immediately connected with Liverpool have been promised.

M. Janssen, we are glad to see, has been appointed to represent the Paris Academy of Sciences, at the inauguration of the statue to Arago, at Perpignan.

THE prizes instituted by Prof. Schäfli (Lausanne) for scientific works on Switzerland will now be awarded not only to Swiss naturalists, as hitherto, but also to foreign, a resolution in this sense having been accepted at the last meeting of Swiss naturalists.

WE regret to hear of the death of Mr. Edward Edwards, late of Menai Bridge, Anglesey, at the age of seventy-five. For upwards of twenty years he had studied the habits and characters

of marine animals in their native haunts, and his contrivance of the "dark chamber tank" was the first by which these animals could be kept alive and healthy for an indefinite period in confinement, and the principle of which was afterwards carefully recognised in the construction of the Crystal Palace and other aquariums.

THE *Times* Geneva correspondent writes, under date August 22:—"On the evening of August 5, six persons who were standing in the gallery of a *châlet* in the Jura, above St. Cergues, witnessed an atmospheric phenomenon equally rare and curious. The aspect of the sky was dark and stormy. The air was thick with clouds, out of which darted at intervals bright flashes of lightning. At length one of these clouds, seeming to break loose from the mountains between Nyon and the Dôle, advanced in the direction of a storm which had, meanwhile, broken out over Morges. The sun was hidden and the country covered with thick darkness. At this moment the pine forest round St. Cergues was suddenly illuminated and shone with a light bearing a striking resemblance to the phosphorescence of the sea as seen in the tropics. The light disappeared with every clap of thunder, but only to re-appear with increased intensity until the subsidence of the tempest. M. Raoul Pictet, the eminent chemist, who was one of the witnesses of the phenomenon, thus explains it in the last number of the *Archives des Sciences Physiques et Naturelles*:—"Before the appearance of this fire of St. Elmo, which covered the whole of the forest, it had rained several minutes during the first part of the storm. The rain had converted the trees into conductors of electricity. Then, when the cloud, strongly charged with the electric fluid, passed over this multitude of points, the discharges were sufficiently vivid to give rise to the luminous appearance. The effect was produced by the action of the electricity of the atmosphere on the electricity of the earth, an effect which, on the occasion in question, was considerably increased by the height of the locality, the proximity of a storm-cloud, and the action of the rain, which turned all the trees of the forest into conductors."

A YOUNG female gorilla is now being exhibited at the Crystal Palace.

AT the last meeting of the Swiss Naturalists, Prof. Kollmann (Basel) presented a report of the Anthropological and Statistical Commission, appointed by the Swiss Natural History Society for the investigation of the distribution of the light-coloured and dark-coloured population in Switzerland. Thanks to the collaboration of many schoolmasters, no less than 250,000 children in twenty-one cantons were described as to the colour of the eyes, hair, and skin, and a very rich and reliable material was collected. It is proved that in Switzerland, as well as in all middle Europe, the light-coloured population decreases from north to south, while the dark-coloured increases, and that it reaches its greatest quantity in the Graubünden, sending a rather dense branch to the south-west. It may be concluded that a dark-coloured population immigrated in Switzerland from the south, having also a side-branch which followed the direction from the Rhone to the Rhine.

WE are glad to learn that the great undertaking of printing and publishing a catalogue of the Advocates' Library, Edinburgh, which has been in progress for many years, is now approaching completion. The Library of the Faculty of Advocates ranks next to the British Museum and the Bodleian among the libraries of the United Kingdom. It contains about 262,000 printed volumes, besides manuscripts of great interest and importance. It has had (under the Copyright Act) since the reign of Queen Anne the right of receiving a copy of every book published in the United Kingdom. Last year there were added to the Library 4,007 volumes of books, besides periodicals, pamphlets, and

music. The Catalogue consists of six volumes and supplement—containing over 200,000 entries—and extending to more than 5,500 quarto pages in double columns. Some idea of the expense of making and printing such a catalogue may be formed from the fact that individual Members of Faculty have already contributed, in donations and subscriptions, a sum of 3,700*l.* About 25*o*l. are still required to print the supplement. It is expected that the work will be completed in September next, and the Advocates' Library will then be the only great library in the world possessing a complete printed catalogue. The value of this work will consist not merely in its making known the peculiar treasures of the library, but in its being the only approximately complete catalogue of all works published in the United Kingdom since the reign of Queen Anne, arranged not merely in the alphabetical order of the authors' names, but to a considerable extent also under leading subjects. Further, more information will be found in it on anonymous and pseudonymous English and Scotch literature than in any other catalogue; and a more extensive analysis of historical and other collections than can be had anywhere else. As regards biographical information, there will be found under each author's name cross-references to all books in the Library written about him or his works. We believe the Library has also a fair collection of scientific works. A copy can be had by addressing "The Keeper of the Advocates' Library, Edinburgh."

It is with pleasure that we announce the completion of the second edition of "Die Urwelt der Schweiz," by Oswald Heer. Herr Schulthess, of Zurich, is the publisher.

In its *Fahresbericht* for 1878 the "Bienenwirthschaftliche Hauptverein im Königreiche Sachsen" publishes the following highly interesting statistical data referring to the indirect utility of bees:—It has ever been one of the objects of all apicultural societies to prove the great importance of bees to agriculture generally. It appears that the Society named possesses 17,000 hives from each of which 10,000 bees fly out daily, which represents a total of 170 millions of bees. If we suppose that each bee undertakes but four journeys per day and that this takes place only on 100 days out of the 365, then we obtain a yearly total of 68,000 millions of bee-journeys. It is not too much to suppose that fifty flowers are visited on each journey, and we are certainly justified in supposing that five out of these fifty are fertilised; then we get a grand total of 340,000 millions of fertilised flowers per year. Let the value of fertilising 5,000 blossoms be but 1 pfennig (or 500,000 for 1*s.*), then the work done by bees of the society represents a value of 68 million pfennige, or 34,000*l.* sterling. It results from these calculations that each hive benefits agriculture to the amount of 2*l.* annually, a value which hitherto has been totally overlooked.

NEWS from Moscow states that a kind of subterranean conflagration is raging upon the islands and the shore of the Kurgaldschin lake in the district of Akmolinsk, province of Atbosarsk. It began in April last, and in the middle of June was still burning with unabated force. The fire spreads in the foot-deep layers of dry reeds, and has penetrated as far as the winter camps of the Kurgaldschin Wolostg, where some 120 Kirghise farms have perished through the flames.

AN international special exhibition of agricultural machinery, &c., will be held at Prague from September 27 to October 5 next.

THE well-known geologist Prof. Credner, has recently proved that in the western part of Saxony glaciers have formerly existed, by the discovery of numerous polished and grooved surfaces of porphyry rocks, now imbedded in the inundation deposits of more recent geological periods. From this discovery

it seems that the Scandinavian ice at some epoch reached as far as the neighbourhood of Leipzig, *i.e.*, to the southern border of the North German plains.

NEAR Wildeshausen (Oldenburg) a so-called window-urn has been found in a prehistoric sepulchral mound. The urn is of elegant shape, perfectly smooth, only ten centimetres in height, and consists of bright gray fine clay. In the body of the urn there are three round holes of about two centimetres in diameter; into these holes green pieces of glass were let in when the clay was still moist. Another piece of glass is in the foot of the urn. Inside the urn stood a vase of the same material and almost the same height. The contents were bones and charcoal. Up to the present, as far as is known, only six window urns have been found; the one described would therefore be the seventh.

MR. MORRIS'S recipe for the cure of the coffee-leaf disease in Ceylon appears to be the application of caustic lime in the proportion of two or three parts to one of flowers of sulphur. He maintains that the disease can only be successfully treated at one of its three stages—the filamentary—when the mixture described will kill the filaments. Mr. Morris is about to publish a handbook on the treatment of this scourge of the island, and by latest advices it appears probable that, at the earnest request of the planters, his departure from Ceylon to Jamaica will be indefinitely postponed.

THE *Echo du Japon* states that the works established at Tsukudu-shima for making carbonate of lime are proving very successful, and will, it is said, send a great quantity of the product to China.

NEAR the village of Eisenkappel (Carinthia), at the border of a forest, several new mineral springs have been discovered about the end of July. They originate in the bed of syenite granite which passes in the direction from Ebriach to Schwarzenbach, and are particularly rich in carbonate of soda, as well as in free and dissolved carbonic acid.

WE notice a very useful Russian pamphlet by M. Lukashevich, on arrangements for heating and ventilation, being a critical description of the various heating and ventilating apparatus exhibited at Cassel in 1877, during the first international exhibition of these apparatus. When we take into consideration how much remains to do in that branch of our knowledge, we cannot but welcome every good work on the subject.

THE *Report and Transactions* of the Cardiff Naturalists' Society for 1878, contains several scientific papers creditable to the members. The Society's Museum has been much improved.

A VOLUME of some interest in connection with progress in Spain has been published by Prof. A. Calderon Arana, "Movimiento Novisimo de la Filosofia Natural en España." It is published at the Casa editorial de Medina, Madrid.

THE additions to the Zoological Society's Gardens during the past week include a Guinea Baboon (*Cynocephalus sphinx*) from West Africa, presented by Mr. P. Lembery; a Bush Dog (*Icticon venaticus*) from British Guiana, presented by Mr. J. Ernest Tinne; a Ring-necked Parrakeet (*Palaeornis torquatus*) from India, presented by Mrs. Watson; a Common Cuckoo (*Cuculus canorus*), British, presented by Mr. J. Sharpland; a Common Barn Owl (*Strix flammea*), British, presented by Mr. H. Norris; a Chacma Baboon (*Cynocephalus porcaricus*) from South Africa, deposited; four Common Spoonbills (*Platalea leucorodia*), European, eighteen Chestnut-breasted Ducks (*Anas castanea*), an Adelaide Parrakeet (*Palaeornis adelaida*) from Australia, purchased; a Cape Buffalo (*Bubalus caffer*), born in the Gardens.

OUR ASTRONOMICAL COLUMN

DR. JOHANN LAMONT.—The death of Dr. Lamont, so long connected with the Royal Observatory of Munich (Bogenhausen), was mentioned last week. He was of Scotch extraction, and was born at Braemar on December 13, 1805. He was at first assistant at Munich, under Soldner, and was appointed director of the observatory in 1835, and Professor of Astronomy in the University of Munich in 1852. His name has, perhaps, been chiefly associated with terrestrial magnetism, his first publication on this subject being the "Handbuch des Erdmagnetismus," which appeared in 1838. In 1851 he wrote on the ten-year period of magnetic declination, of the existence of which he was an independent discoverer, and the same year he published at Stuttgart his "Astronomie und Erdmagnetismus," and a long series of memoirs bearing upon magnetical science is due to him. He is also the inventor of a set of instruments for determining the magnetic elements very widely used by continental magneticians. As an astronomer we find him occupied with the observation of Halley's comet with the refractor of eleven inches aperture, erected in 1835, by means of which he was able to follow the comet until May 17, 1836, nearly a fortnight later than it was seen by Sir John Herschel, with his 20-feet reflector, at the Cape of Good Hope, the last glimpse of the comet being thus obtained by Lamont. It was then distant from the earth 2'69, and from the sun 1'86, so that the intensity of light was almost precisely the same as when the comet was first detected by Dumouchel at Rome, August 5, 1835. In 1836 he calculated elements of the Saturnian satellites *Enceladus* and *Tethys*, which had been observed at Munich, and also discussed Sir W. Herschel's observations of the latter. In the summer of this year he measured the diameter of Pallas, and formed charts of stars in the clusters in Scutum and Perseus. In the following year he made a series of measures of the two brighter satellites of Uranus, and deduced from them a value of the mass of the primary considerably less than that previously adopted from Bouvard's tables. The most extensive astronomical work executed at Munich under Lamont's direction is the observations of zones of stars from +15° to -30° published in successive volumes of the *Annalen der k. Sternwarte bei München*, and in the previous series; various catalogues founded thereon, and containing together upwards of 30,000 stars reduced to the year 1850, have been published in the supplementary volumes of the *Annals*. Mr. Hind found in Lamont's zones two observations of Neptune before its planetary character was recognised. The magnitudes of the telescopic stars in these zones will prove serviceable from time to time in the investigations of the periods of variable stars.

THE SATELLITES OF MARS.—Prof. Asaph Hall, after discussing the long series of observations of the newly-discovered satellites of Mars made with the Washington 26-inch refractor in 1877, expressed the opinion that at the approaching opposition of the planet these objects will be observable with that instrument from about October 10 to November 29. It may therefore appear almost hopeless to expect measures as early as September, yet probably efforts may be made in this direction and with the view to facilitate the identification of the outer satellite, *Deimos*, we subjoin positions calculated from Prof. Hall's elements for 13h. Greenwich mean time:—

	Pos.	Dist.		Pos.	Dist.
Sept. 11 ...	235°5'	48°5'	Sept. 16 ...	238°7'	46°5'
12 ...	296°3'	10°3'	17 ...	8°5'	12°7'
13 ...	49°9'	46°9'	18 ...	53°1'	51°7'
14 ...	68°3'	30°0'	19 ...	80°0'	19°8'
15 ...	221°6'	33°2'	20 ...	227°1'	43°6'

The greatest elongations of the satellites occur at angles

of about 53° and 233°, the greatest apparent distances at the next opposition being 67" for *Deimos* and 27" for *Phobos*, the former passing the extremity of the minor-axis of the ellipse about seven seconds distant from the limb of the planet.

GEOGRAPHICAL NOTES

HERR OTTO SCHÜTT, the well-known African traveller, has returned to Lisbon from his exploring expedition to Central Africa, undertaken by order of the German African Society, and has delivered an interesting lecture to the Lisbon Geographical Society. He brings home highly important and quite new data concerning the complicated hydrography of the Congo Basin. Between the Cuango and the Casai rivers, two known tributaries of the Congo, he has discovered four others, viz., the Quengo, Marata, Cinlu and Quanger rivers. Besides this he has determined the upper course of the Casai river from lat. 8° S. to about lat. 6° S. in a district totally unknown hitherto. From lat. 8° S. as far as lat. 4° S. the Casai takes the name of Zaire, which on older maps is often given to the Congo itself. The lake called Sankowa Lake by English explorers is situated in lat. 5° S., and is called Mucaruba by the natives. To the south of this lake a tribe of dwarfs are living. The tribes inhabiting the shores of the Quengo and the Casai rivers are cannibals. As the Muata Jamvo, who some three years ago stopped Pogge's further progress, did not permit Herr Schütt to cross the Lulua river, he had to return to Loanda on the west coast.

IT is announced from Sierra Leone that Mr. H. M. Stanley arrived there on July 24, and left on August 1 for "Banana" (? Mboma), on the Congo.

INTELLIGENCE has been received at New York of the arrival of the Polar exploring vessel *Jeannette* at Onalaska, on the 2nd inst. She is to endeavour to meet with Nordenskjöld in Behring Strait. The United States Revenue vessel *Richard Rush* has passed through Behring Strait, within seventy-five miles of East Cape. Her captain reports that the sea northward of that point is clear of ice. Last winter had been unusually warm, and the ice broke up earlier than usual.

SEVERAL Russian expeditions are to be sent out during this autumn to Central Asia, and especially to the Darwaz. Capt. Hermann and the well-known young botanist, M. Smirnof, will explore that quite unknown country, and M. Smirnof will no doubt bring back a rich botanical collection.

A TELEGRAM has reached St. Petersburg through Pekin from Col. Prijwalsky, to the effect that at the date of his despatch his expedition had accomplished the third part of the route to the Himalaya, and that no great obstacles were expected to intervene between them and their desired goal—which may mean Lhasa.

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. No notice is taken of anonymous communications.]

[The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.]

How did Eozoon Originate, and is Graphite a Proof of Organic Beings in the Laurentian Period?

I READ with great interest the abstract of Dr. Moebius's investigations on Eozoon in NATURE, vol. xx. pp. 272, 297, and no more doubt of its inorganic origin. But how was Eozoon formed? We find such single or ramified foraminifera-like or algae-like fibres or stems (Figs. 5, 9, 10, 18, 19), which show,

by their irregularity, that all organic origin is excluded, sometimes in ice; they originate in the hardening together of crystals, under pressure, and are only the imprisoned, often stem-like and branched hollows of air. Like Eozöon they become afterwards filled with foreign matter, with serpentine and chrysotile, resulting out of the watery decomposition of olivine.

To show how analogous circumstances are also applicable to the origin of Eozöon, I shall first refute the two erroneous arguments often adduced for the organic existence in the laurentian period: the presence of graphite and the stratification of the oldest rocks.

Graphite, as Dr. Moebius supposes, cannot be a sign of primitive organic life. (1) In the oldest period there certainly lived only the most primitive lower beings, which without exception decay rapidly, and are therefore not able to furnish coal. (2) Graphite is sometimes a substitute of mica in the Gneiss; if it be phytogen, the synchronous quartz and feldspar, &c., must also be declared so; but that is absurd. (3) We always get amorphous coal out of organic beings, and by chemical process in the cold way, and on the contrary crystallised coal, i.e. graphite, is only to be produced by heat, and in several ways, even out of gases. We must regard graphite as one of the arguments, proving the incandescent origin of the oldest rocks. Out of each kind of coal, also of graphite, bitumen can originate, so that bitumen is not always a sure proof of organic beings. (4) There exist many other facts proving the incandescent origin of laurentian minerals; I will add, as I believe, a new one. This origin excludes at the same time any living beings. Not one original mineral of the laurentian minerals contains water, only mica contains a very small proportion, but this chemically combined, for it cannot be expelled at red-heat. If these minerals had not had their origin in heat, they would sometimes contain water.

The other fallacious proof for the neptunic origin of laurentian rocks is their occasional stratification, and this origin would include the possibility of organic beings. No geogenetic hypotheses have been able to combine the facts of heat origin and stratification! But if we change the generally adopted opinion of Kant and Laplace, that the gases of the atmokosmos formed our globe by being condensed first into incandescent liquids, and finally into crystals, we may combine all the facts.

It is often found that we get out of hot gases mostly crystals, which partly by chemical reaction, become at first incandescent, and even quartz, feldspar, granite, and some iron minerals that we find in the granite, are known to be produced crystallised out of gases. Other facts prove that these laurentian minerals must have originated between white and red heat.

In the origin of glaciers we have an analogy for the agglomeration of the incandescent crystals into the first earth-crust without melting, only by baking together, as being somewhat plastic, the crystals of snow harden together into ice, driving out the air between the crystals and losing their crystallised surface, assuming also sometimes Eozöon-like forms. Glaciers not seldom show stratifications, especially in the upper part formed by temporary snow-falls. As on the top of the glacier the snow-crystals lie yet ununited, so the minerals of the laurentian period were certainly lying ununited upon the surface, and became afterwards hydrated together, when the earth-crust was cool enough, so that we find them in the post-laurentian period much more mixed and with products of neptunic erosion.

OTTO KUNTZE

Leipzig-Eutritzsch, August 2

Unobserved Impressions

A NOTE to Mr. Mivart's address in the Biological Section of the British Association contains the following:—

"Having gazed vacantly through a window we revert to the pages of a manuscript we may be writing and see there the spectra of the window bars we had before unconsciously seen. Here the effect on the organism must have been similar to what it would have been had we attended to it—i.e., it was unfelt sensation" (NATURE, vol. xx. p. 399).

The last words induce me to mention what I believe I have often observed but have hitherto presumed to be well known in psychophysics, because though they are not inconsistent with it they seem to show that it had escaped the speaker; namely, that an unobserved impression produces a much stronger effect on the organism immediately impressed than an observed impression. Of course the observation cannot be experimentally prepared; but if any one who experiences a case like that

described by Mr. Mivart will allow the image to fade and then try to form another of the kind, he will be struck I believe by the inferiority of the voluntary one.

The phrase "unfelt sensation" suggests questions I wish to keep clear of; but the phenomenon appears to me interesting, because it plainly shows that work which would be done on the retina, or on something, by an unobserved impression, is done elsewhere by an observed one.

C. J. MONRO

Chesterfield, August 24

Insect-Swarms

A WONDERFUL flight of insects has passed over here to-day, consisting of the butterfly *V. cardui* and the moth *P. gamma*. They all came from the sea from the north-west and passed over the land to the south-east. I first noticed the flight at 7.30 A.M. The morning was bright and sunny with a light wind a little south of east. Great numbers of *V. cardui* were soaring at all heights, up to at least 150 feet, above and between the poplars which surround the house in which I am staying; all were going leisurely to the south-east; lower down *P. gamma* more erratic in its flight, was going in numbers in the same direction. I went down on to the grassy slope above the shore cliff. The blackberry blossoms were covered with *V. cardui* and *P. gamma*, three or four on a flower, the fussy moths much disturbing the more sedate butterflies, but each bent on holding its own. With scarcely an exception they took flight in a south-east direction when disturbed or when satisfied with their often, I fear, vain search for food. I stepped fifty paces from a clump of dark firs at right angles to their line of flight and counted the butterflies which passed for two intervals of two minutes; the numbers were 95 and 108, but I probably missed some of the higher ones. On the shore at 10 o'clock I counted 73 in one minute pass a space 50 paces in width; at 11.45 in one minute 50 passed the same space. The numbers of *P. gamma* were more difficult to ascertain owing to their smaller size and more erratic flight, but as they all flew very low on the shore, not more than a foot or two at most above the water or sand, I stepped 20 paces and tried to count the moths passing within those limits with the result—one minute 32 moths, two consecutive minutes 18 moths, again two minutes 120 at least. In the second interval a strong gust of wind checked the flight altogether, and in the third interval the moths came so fast that I missed many I feel sure. The *P. gamma* were evidently much exhausted; while bathing I saw several floating on the surface of the water, which took flight when touched or crawled on to a finger presented to them; some settled on me and on others while we were bathing. At 12 o'clock I passed uninterruptedly through the flight while walking from Trouville Harbour for a distance of two kilometres northwards along the shore. There was then an occasional white butterfly (*Pieris*) in the flight, and I also noticed two dragon-flies coming from the sea and following the same direction as the other insects; I noticed other dragon-flies with the flight inland, but they abound here. Had those coming from the sea accompanied the flight throughout as hawks are said to follow the flights of birds on which they prey? From the shore I climbed up the cliff, the grassy slopes above it were swarming with *P. gamma* and *V. cardui*, nearly every flower having one visitor at least. At 1.15 P.M. *P. gamma* passed over in undiminished numbers, but *V. cardui* was not so abundant. At 5.30 I rode parallel with the coast line along the Honfleur road to a point rather more than 10 kilometres from Trouville, passing through an uninterrupted flight of *P. gamma* all the way, but no *V. cardui*, though the butterfly still abounded on the blackberry and other blossoms by the roadside. Throughout the last two kilometres the moths were much fewer in number, but had not quite disappeared when I turned back. *P. gamma* generally flew lower than *V. cardui*, but the force which impelled them in one direction, as if their bodies were magnetised and their north pole was in the south-east, was so strong that when they met an obstruction to the course of their flight they went often over it not round it. While riding I noticed that they rose up and flew over isolated buildings, and I was curious to see whether they would do the same with a church tower. As I passed through Villerville, three came over the top of the church tower, and again at Criquebœuf, three fluttered up the wall, and flew over the church tower as I passed it. At 8 P.M. I went up on to the roof of the house; the moths were then flying up the front of the house and over the roof in great numbers. The flight of *P. gamma* continued to pass the

house in which I am writing, without interruption, from 7.30 A.M. till dark, and are now at 11.30 P.M., flying in at the open window, so as to be a perfect nuisance. They are still tired moths, for they soon settle; there are certainly many hundreds in the dark corners and along the cornice.¹ My children tell me that numbers of the moths were lying dead on the dry sand above high-water mark.² They collected some for a tame young magpie, which has been very happy all day among the flower-beds in the garden catching *P. gamma*, which, under ordinary conditions, would be far too wide awake for him.

How far the flight extended south of Trouville I do not know, but the number of insects which have passed from sea to land here to-day must be very great. Assuming that one *P. gamma* passed over each metre of shore line each minute, an estimate below the mark at all points to which my observation extended, and assuming the flight to have extended 10 kilometres along the shore, as I ascertained that it did during the evening, nearly 8,000,000 of *P. gamma* passed from sea to land between 7.30 A.M. and 8.30 P.M.

All the insects which I caught or looked at on flowers were in perfect condition.

Where have all these insects come from? Has the flight been noticed in England? *V. cardui* was exceedingly abundant here in June and throughout July, indeed it was the only butterfly to be seen in any numbers. Its larvæ have been feeding in tolerable numbers on the thistles and other plants, and some few fresh specimens appeared before the flight of to-day, but I think there is no doubt the insects which formed to-day's flight were not bred here. Why should the moth and the butterfly come together? Here they were flying against or nearly against, the wind, although they may have started with a favourable wind. Where will they go to? If they go far, what influence will they have on cross-fertilisation? The quantity of pollen which they will carry onwards from the myriads of flowers they have visited will be immense. Perhaps other observers may answer some of these questions.

J. CLARKE HAWKSHAW

Trouville, Calvados, France, August 12

P.S.—The flight still continues this morning, August 13, 10 A.M.; *V. cardui* quite as abundant as yesterday.

P.S. No. 2.—The flight of *V. cardui* and *P. gamma*, described in my letter of August 12 ceased about 12 A.M. on the 13th. At 11 A.M. I counted forty-six and twenty-four *V. cardui* on the shore passing over a space of fifty yards in width, in two intervals each of two minutes. Judging from their number, the *V. cardui* have not remained here; on the other hand, I think many of the *P. gamma* have. On the 14th a large clearing in the forest of Tonques, about two miles inland, was alive with them. The flowers of the wood-sage appeared to be the great attraction there. I noticed many *P. gamma* lying dead on the roads inland, all in perfect condition. I believe that these moths died of starvation. The moths which flew into the house on the evening of the 12th were all more or less sluggish in the morning. There were more than 400 on one window, many of which readily took food offered to them in the form of syrup, and I induced a number of those in the forest to come on to my finger and suck up syrup.

What I have seen leads me to make the following suggestions as to the cause of these migrations of lepidoptera.

When a favourable season produces a great swarm of insects numbers would die from want of food if they remained where they came into existence, as the number of food-producing flowers is limited. To move off in some direction would be a necessity, and in time the impulse to migrate would become instinctive as soon as the want of food was felt, or even the presence of a crowd of their fellows. It would seem that the supply of food might be most readily found if the insects moved off in all directions, that is, spread from the centre of scarcity; but many moths seek their food by scent, and on that account generally, I believe, fly against the wind. Many facts might be given to show how acute the power of scent in moths is. Whether butterflies seek their food by scent or not I do not know; some are certainly attracted by strong odours, *Apatura iris*, for instance. At any rate, I think a hungry moth would fly against the wind, and so the general direction of a flight of moths might be determined.

Here both butterflies and moths searched the first flowers they came to after leaving the sea. The first comers would go on

refreshed, but the later ones merely wasted their energy in a fruitless search, and many of the moths fell dead by the way.

In the case of the flight I have described, a double necessity for the migration would have arisen if the butterfly and the moth came into existence at the same time as, seeing their fine condition, they most probably did. As both appeared to search the same flowers, the dearth of food at their centre of departure would more speedily have arisen.—J. C. H.

August 23

Animal Rights

MR. ROMANES'S parallel is as unsound as amusing. If a physiologist claimed to vivisect his children "on the plea that it was for this purpose that he had begotten them," we should tell him that the legal admission of such pleas would undermine human society. But in the killing of pigs for food no undermining of human society is involved. Moreover, we know that men breed pigs only to kill them, but that men breed children from entirely different motives; we should answer the physiologist that his plea was impossible of proof, that all human experience negated its probability, and that consequently it could not be admitted to overrule his children's presumptive right of life.

Mr. Romanes repeats his amazing proposition in morals, that "if we have a moral right to slay a harmful animal in order to better our own condition, it involves an inconsistency to deny that we have a similar right to slay a harmless animal, if by so doing we can secure a similar end." Then, if we have a moral right to slay harmful Zulus to better our own condition, we have a similar right to slay harmless Eskimos, if by so doing we can secure a similar end!

Mr. Romanes says that I did not attempt to meet one of his criticisms. Had I thought I might, I would have met them all; it does not take long. He thinks a lobster, to whom might is right, could not convince a philosopher that the latter had no right to eat him. Then I may pick a thief's pocket? He next admits that the lobster might appeal to the philosopher's morality, but asks why "the right of an edible animal to live is superior to that of an eating animal to kill?" Then the right of a robbable man to his money is not superior to the right of a man who uses money to rob him? And I, who am edible, have no more right to live than a cannibal has to eat me? Lastly, Mr. Romanes makes his philosopher say that he prefers lobster salad and roast lamb to boiled snakes and rat pie. Preferences are not rights, but if they were I have not suggested that the latter diet should supersede the former; and so my withers are unwrung.

EDWARD B. NICHOLSON

[*Ergo* the rights of a pig are *not* the same as those of a baby, which is just the point which my purposely unsound parallel was intended to show. It is for Mr. Nicholson to prove that the parallel is *sound*, if he is to sustain his "erroneous premiss," that the rights of men and animals are identical (the objection as to "motive" I ignore, because on the erroneous premiss in question the physiologist's motive might be sincerely stated and adequately proved as a motive by a declaration, say, in the marriage settlements). Instead of doing so, however, he alludes to one important difference between the rights of an animal and those of a man—the difference, namely, which arises from the latter being a member of human society. And this difference is in itself sufficient to nullify the force of all his rejoinders. Only on Mr. Nicholson's own supposition, that the rights of all living things are identical, could any of my propositions made with reference to animals be tested by their applicability to men. But this is just the supposition which I regard as absurd, and because it seems to me that ethical doctrine is here sufficiently patent—viz., that man as an intellectual, moral, and social being has rights additional to those of a merely sentient being. I will not take any further part in this correspondence.]

GEORGE J. ROMANES

Alpine Clubs

IN your account of the late conference of Alpine clubs, held at Geneva, there is one little omission which, as interesting to the scientific world generally, I beg leave to remedy.

It was suggested by your humble servant that a re-publication of de Saussure's "Voyages dans les Alpes" would be an appropriate memorial of our little congress at the city of which he was, I may say yet is, so bright an ornament. My plan was to

¹ I have counted 200 on one part of the cornice.

² Possibly killed by the heat of the sand, on which they settled in an exhausted state.

add the matter necessary to bring his work up to date in science, within square brackets (as in Stephen's edition of "Blackstone's Commentaries"), or as notes, or even as an appendix, the whole work to be in the hands of an efficient committee. The proposition was very cordially received, and I should like to hear what English men of science think of the matter. The book is of the freshest, brightest nature; even as a small boy I delighted in it; and my own idea is that de Saussure, though necessarily behind the giant strides of modern knowledge, made so very few mistakes that re-publication would not have the same dangers for his reputation as it might for that of a mere mediocrity.

MARSHALL HALL

Vernex-Montreux, Canton Vaud, Switzerland, August 19

"Report of an Unusual Phenomenon Observed at Sea"

I CAN supply a second instance of the "unusual phenomenon observed at sea," communicated by the Hydrographer of the Navy to NATURE, vol. xxi. p. 291.

One night in April, 1875 (I cannot give the exact date, as my notes were lost in the ship) H.M.S. *Bulldog* was lying becalmed in a glassy sea off a point of land a few miles north of Vera Cruz, when a line of light appeared along the northern horizon, and unaccompanied by the least breath of wind, swept towards and past the ship, in a series of swift luminous pulsations, precisely similar to those described by Mr. Pringle. Acting on the old sea formula, "observed a phenomenon, caught a bucketful," we dipped up some of the water, and found noctiluce and crustaceans in it. These may have supplied the luminosity, but if so, the exceedingly swift-travelling cause of their stimulation would still remain unaccounted for.

A squall accompanied by incessant thunder and lightning overtook the ship the same night.

EDWARD L. MOSS

Rathgar, Dublin, August 19

Boring Molluscs

THE following extract from Prof. Joseph Leidy's paper on "Vertebrate Remains, chiefly from the Phosphate Beds of South Carolina," which appeared in NATURE, vol. xx. p. 354, will serve in aid of the solution of the still open question, By what means do the boring molluscs penetrate hard rocks?—"The fossils mainly consist of the harder parts of the skeleton and of teeth, usually more or less water-worn, indicating shallow seas and an active surf to which they were exposed. Many of them exhibit the drilling effects of boring molluscs, especially those which are supposed to have been derived from the tertiary marl rock, the operation of drilling apparently having been performed both before and during the time the fossils were imbedded in the rock. Only enamel, or the enamel-like dentinal layer such as is found investing the crown of the teeth of sharks, appears to have been a protection against the drilling power of the borers."

Were the burrows produced by the solvent action of an acid, there is no reason why the enamel should have arrested the solvent rather than the dentine, although it might yield more slowly to it; but its refractory behaviour under friction accounts for the Pholades and Terebrines being nonplused; while their desistance from fruitless efforts affords an instructive example of pure *instinctive* action, *i.e.*, reflex action "the prompting to which is given by sensations."

PAUL HENRY STOKOE

Beddington Park

Intellect in Brutes

A CORRESPONDENT of yours tells a tale (NATURE, vol. xx. p. 338) about a cat ringing a bell to be let in. Without any wish of "topping" this tale, I think the following will go far to demonstrate the existence of a thinking power in the brute brain, if indeed that fact is ever doubted:—

Some relatives of mine living in Sussex owned a very intelligent dog of somewhat doubtful breed, having, however, a decided touch of the French poodle in his composition. In addition to this animal they also had a favourite cat. For some time they were bothered in the way your correspondent describes by runaway knocks, instead of rings, as in his case; however, they discovered that the cat had learnt to stand on her hind legs and reach the knocker which was low on the door, and to knock distinct and separate double knocks until she was admitted. This in itself was curious, but a short time after they discovered this fact they discovered another still more curious. They were in the habit of turning the dog

out every evening for an airing. It invariably happened that if the cat was out of the house at the same time, that a short time after the dog was turned out they would hear a knock at the door. On its being opened both animals would be found outside and would immediately come in, the dog always allowing the cat to precede him. There seems to be no doubt that the dog finding out that the cat could obtain entrance was in the habit of searching for her when he wanted to come in, and either waiting till she was ready to knock at the door, or of inducing her to do it to please him. I can myself vouch for the above facts.

W. H. KESTEVEN

Holloway, August 13

MR. LAYARD's letter mentioning the bell-ringing cat leads me to send the following account of a wise old Scotch collie with which I was personally acquainted. Toby, belonging to my friend Mr. T. F. Hancock, formerly of Tyes Place, Staplefield, Sussex, was passionately fond of his vocation, but at the same time made much of in the parlour. On one occasion, while lying in front of the fire in the dining-room, he heard sheep going by the house along the farm-road. He ran to the window-seat and then to the door, at the same time looking imploringly at my friend's sisters, as if to beg them to let him out. This, however, they declined to do, and after one or two journeys between window and door, he ran to the long, old-fashioned bell-pull, rang the bell, stood at the door, and bolted out and round into the kitchen as soon as the servant appeared.

After this Toby was constantly employed during meals to ring the bell, and I have myself often made him perform the operation, which was always accompanied by a good deal of barking. My friend has a more than life-sized painting of this wise dog, painted by the late Charles Hancock, the animal-painter.

One more instance of reasoning I will relate. A few months ago my wife and I were bathing a cocker dog in the stream flowing through the grounds of St. Helen's, Coker-mouth. We threw a croquet-ball into deep water, and the dog was to bring it to shore. But the ball was rather large for the size of her mouth, and as often as she snapped at it the ball glided away. After vainly endeavouring to grip the ball, we watched her suddenly give over, and begin pawing it with her fore-feet until she brought it into shallow water, when she easily made the capture, and brought the ball to the bank. The same was repeated several times. It is unnecessary to say that this was not the result of teaching.

J. CLIFTON WARD

Keswick, August 14

As your pages have for some time drawn attention to such inquiries, I wish to ask if any one ever saw a favourite dog, or other animal, stop to gaze at a rainbow? We have never heard of such a case; but if ever encountered a record in your pages is invited.

BENJ. ALVORD

Washington, August 7

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