THURSDAY, AUGUST 11, 1881

VIVISECTION AND MEDICINE

THE International Medical Congress which has met in London during the past week is the largest that the world has ever seen. Medical men have assembled from every part of the earth, and their meetings seem to have been productive of general satisfaction. The objects of such a Congress are twofold—first, to tell or hear of new discoveries; and, second, to make men personally acquainted who have previously been known to each other only through their works. The latter is perhaps the more important of the two, for it is not only a source of very great pleasure, but of great profit, inasmuch as it enables men to form a juster appreciation of the workers in each department of medicine, and to avoid falling into the error, very common at the present day, of placing the observations and opinions of a mere tyro on a level with those of the scientific veteran. The work of the Congress has been divided into no less than fifteen sections, each of which has taken up some special department of the science or practice of medicine. For medicine is now not merely an art. It is no longer practised by simple rule-of-thumb. It is becoming, to some extent, a science, and exact knowledge is beginning to supplant blind empiricism. The means by which this change has been effected have been admirably illustrated in the addresses of Prof. Virchow, Mr. Simon, and Prof. Fraser.

They are those of experiment.

It is by experiment alone that we are able to distinguish between facts and fancies, between the ideas which arise in men's minds and the realities of the external world. It is in proportion as we bring our ideas into accordance with facts, or, in other words, as we *know* instead of *supposing*, that our power increases. Suppositions have been the *bête noire* of medicine. They have constantly misled men as to the causes, the nature, and the treatment of disease, and so long as they were not subjected to the test of experiment one supposition succeeded another, only to be itself replaced by a third, no less fanciful and no less delusive. This is the reason why the progress of medicine was formerly so slow, and it is only of recent years, since the experimental method has been employed, that medical knowledge has begun to acquire any exactitude. As Prof. Virchow points out in his address, the principle of modern medicine is localisation. We localise the causes and seats of a disease, we localise the action of remedies, and thus we are able to act with certainty so far as our knowledge will carry us. If we were able to localise certainly and define accurately the causes and seats of disease and the action of our remedies, we should possess a power to arrest or prevent disease which would render death by old age the usual, instead of as at present the exceptional, termination of human life. The experiments by which exact knowledge is obtained are, as Mr. Simon points out in his address, of two kinds. "On the one hand we have the carefully pre-arranged and comparatively few experiments which are done by us in our pathological laboratories, and for the most part on other animals than man; on the other hand, we have the experiments which accident does for us, and, above all, the incalculably large amount of crude experiment which is popularly done by man on man under our present ordinary conditions of social life, and which gives us its results for our interpretation." As an example of these two kinds of experiment, Mr. Simon quotes the classical experiments to which we habitually refer when we think of guarding against the danger of Asiatic cholera: "On the one side there are the well-known *scientific* infection experiments of Prof. Thiersch, and others following him, performed on a certain number of mice; on the other hand, there are the equally well-known *popular* experiments which, during our two cholera epidemics of 1848-49 and 1853-54, were performed on half a million of human beings, dwelling in the southern districts of London, by certain commercial companies which supplied those districts with water."

Popular experiments on the causes of disease are performed everywhere around us. Even when no epidemic prevails, our hospitals are crowded with the sick and dying, and many, very many, of these are dying from lack of knowledge. Probably the most dreaded scourge of this country is pulmonary consumption, or tubercle, as it is sometimes shortly termed, from a pathological product found in the lungs in this disease. This fearful malady seems often to attack the most beautiful and the most gifted. We have hospitals established especially for its treatment, and these institutions are crowded to the door, applicants having to wait weeks, perhaps months, before they can obtain admission. Hitherto we have been accustomed to regard this dreadful disease as one which we had no power to guard against, and whose attacks were no more to be averted than the stroke of a thunderbolt. But increased knowledge has already shown us how to avoid or prevent to a great extent the danger which we might otherwise incur from the lightning-flash, and increased knowledge is now showing us the causes which may induce consumption, and thus teaching us how to avoid them. By experiment upon animals we are learning the nature of the morbid processes which occur in this disease, and the conditions which give rise to them. We are learning that tuberculosis in cows may be communicated to healthy animals fed upon the milk which they yield, and that tubercular disease may also be induced by tubercular matter inhaled in the air or conveyed into the stomach. In these experiments upon animals we are simply repeating in a scientific way the popular experiments which men daily make in blind ignorance upon men. We communicate to a few animals a disease of which men perish by thousands, and by the sacrifice of a few dogs or rabbits we gain knowledge which may enable us to preserve the lives of thousands of men, and avert the anguish which their untimely death would cause to their relations.

In the out-patient departments of our general hospitals there are probably no cases more trying to the humane physician than the cases of consumption which he sees. Racked by cough and worn to a shadow as they often are, the physician knows that he can do but little for them if they are admitted. The utmost that his art is capable of is somewhat to alleviate their sufferings, and perhaps slightly to prolong a comparatively useless life. For these reasons he is often obliged to sacrifice his own feelings, and to refuse admission to the sufferer, knowing that such an act of apparent charity would be real cruelty to others. By putting out of sight for a moment the fact that the number of beds in the hospitals is necessarily limited, and admitting such a consumptive patient, he would gratify his own feelings of kindness and benevolence, but would also exclude the young and strong who suffer from such acute diseases as inflammation of the heart, lungs, or kidneys, diseases which by proper care and attention in the hospital might, and very probably would, rapidly run a favourable course, and result in the patient's restoration to his family in health and strength, but which if left to themselves might damage the constitution of the sufferer and make him a burden on society, or quickly carry him off, leaving his wife a widow and his children fatherless. Although the wistful looks and earnest entreaties of the consumptive patient might lead some few morbidly sensitive and unreflecting persons to open the gate of the hospital to him rather than to the strongly-built and apathetic labourer whose life was in hourly peril from acute disease, yet most people would, in all probability, have little difficulty in deciding between the two cases, were they to apply for admission at the same time. But the case is different when the consumptive is refused, not because the other is already there, but because we know that in the ordinary course of events he must needs come. Here we are forced to disregard the promptings of sympathy with the case before us, and to do that which gives us present pain in order that we may achieve a higher though future good.

Now what occurs daily in the treatment of patients in hospitals, occurs also in the investigation of disease. In order to prevent the suffering, misery, and death of human beings, it is necessary that animals should be sacrificed, and that we should not allow ourselves, for the momentary gratification of those sentimental feelings which would lead us to avoid inflicting even slight and transitory pain upon animals, to neglect the acquirement of that knowledge which will be productive of lasting and widespread benefit to mankind. Many of those consumptive patients probably owe their weary days, their sleepless nights, and their shortened lives to popular experiments, experiments which have been made upon them just as they might have been made upon animals in the laboratory; but they have been made for a different purpose, for the purpose of gain—gain of money, and not of knowledge. These patients may have been supplied with milk from tubercular cows, because it was more profitable for the owners of the dairy to continue milking such animals than to destroy them. Such popular experiments may be carried on for many years without leading to any knowledge of their results, because the conditions under which their subjects live are so complex that it is very hard to ascertain which one of them is the cause of disease. And all this time the unfortunate sufferers from such experiments are suffering and dying for lack of the knowledge which might be acquired by a few experiments on animals in a laboratory. For in experiments n the laboratory the conditions are much more simple, and it is by such experiments on a small number of animals, instead of on an enormous number of human beings, that it has been ascertained that the milk of tuberculous animals is dangerous, and that the seeds of tubercle may be sown in the organism by its use. By similar experiments on a small number of animals in the laboratory we are now learning that many diseases are due to minute organisms, which we can cultivate at will under definite conditions, ascertaining their mode of growth and the influences which modify it. By such experiments M. Pasteur and others have found that these organisms may have their virulence so modified that they can be inoculated harmlessly, and that these inoculations will protect the animal against the virulent form, just as vaccination will protect against small-pox. It is only by an accurate knowledge of the causes of disease that we can hope to prevent its occurrence, and it is only by an accurate knowledge of its nature and seat, and of the action of drugs, that we can hope to cure it when it is present. The seat of disease may be determined without experiment upon animals, for, after the death of the patient, a post-mortem examination will show what parts of the body have been affected. But the alterations which we find in the dead body are only the results of disease. They are no more the disease itself than a field strewn with slain is a battle. As Prof. Virchow remarks in his address, disease presupposes life. In the dead body there is no disease; with death, life and disease disappear simultaneously. It is only in the living body that we can investigate the process of disease, and it is by experiments upon living animals that such exact knowledge of disease as we already possess has been acquired. Without the aid of experiment we are able to ascertain even less regarding the action of drugs than regarding disease, for the most powerful drugs will profoundly alter all the functions of life, and may, indeed, kill almost as rapidly as the lightning-flash, without leaving any visible trace behind to guide us to the seat of action. It is only by experiment upon living creatures that we can ascertain the action of a drug. Formerly, physicians were accustomed to make these experiments upon their patients, "pouring," as Voltaire has said, "drugs of which they knew little into bodies of which they knew less." Nor could they do otherwise. They were called upon to render assistance to their patients, and in their ignorance they did what they could; but instead of being guided by the lamp of knowledge, they followed the *ignis fatuus* of their own imaginations. As Prof. Fraser points out in his address before the Section of Pharmacology, fanciful resemblances between medicines and parts of the body, healthy or diseased, were supposed to show the organs which the medicines particularly affected, and the diseases in which they would be useful. For example, the white spots on the leaf of a plant were supposed to indicate that it would be useful in consumption, because in that disease white spots are found in the lungs. The carrot was employed in jaundice, because the plant and the patient were alike—yellow; and fruits were given in diseases of the heart or kidneys for no better reason than that they resembled these organs in shape. We now laugh at the wildness of these fancies, but we are justified in doing so only because they have been proved by experiment to be foolish. The experiments which proved this have mostly been made by giving drugs to large numbers of human beings, patient after patient being treated in the same way, until the inefficacy of the drug became so apparent that its use was finally abandoned. But while physicians were thus blindly groping after the truth, their patients were suffering or dying. The doctors might *think*, perhaps, that some other treatment would have been more beneficial than the one they adopted, but they did not *know* it, and they were obliged to act according to the best of their belief. They were forced by the circumstances in which they were placed to perform what Mr. Simon terms a "popular" experiment instead of a scientific one, and the complicated conditions under which it was performed rendered it doubtful how much of the result was due to the drug and how much to the disease, so that a conclusion could only be arrived at after an immense number of trials. The method by which pharmacology is now studied is entirely different. Instead of first giving the medicine to a patient labouring under disease, the effect of any new drug is tested upon plants, such as algæ and fungi, and upon the lower animals, such as frogs and rabbits, and its mode of action is then exactly ascertained by means of experiment upon animals, so that before giving it to a human being we not only know what organs and structures in his body will be affected by it, but, to a great extent, *how* they will be affected, and consequently what changes will be produced in the course of the disease for which we administer it. Instead, therefore, of acting blindfold, we are able, almost with certainty, to relieve where we should formerly have been powerless, and to prevent suffering even when we cannot save life. The key-note of the present medical congress, struck by Prof. Virchow in his address, is the absolute necessity of experimentation upon living beings for the progress of medical science. Without experiment we can have no certain knowledge, and without knowledge we have no power to cure and prevent disease and death. Experiment there must be, and the only question is, Upon what living beings are the experiments to be performed, and how are they to be performed? Are they to be popular experiments, such as those to which Mr. Simon alludes, blindly made upon hundreds or thousands of human beings, healthy or diseased, or are they to be made upon a few animals in laboratories? The idea of inflicting pain upon animals is naturally repugnant to every well-regulated mind, and the thought that they are preventing unnecessary suffering is probably one of the greatest pleasures that tender-hearted and sensitive persons can experience. But this pleasure may be purchased too dearly, and by preventing the infliction of a certain amount of suffering upon a few animals a much greater amount of suffering may be caused to thousands of men.

Vivid pictures have been drawn of the suffering of animals in a physiological laboratory, and, misled by these, great numbers of people have been induced to join in the agitation, and consequent legislation, against vivisection, forgetting entirely that the pain inflicted in a vivisection experiment, except in the very rarest instances, is far exceeded, both in intensity and duration, by the sufferings of very many human beings in the course of a mortal disease, and of almost all animals except those slaughtered by man or killed and eaten by other animals. Every winter hundreds and thousands of birds and beasts die of cold and hunger, and hunger and thirst must almost always hasten the death of all wild animals. Sometimes they starve simply because no food is to be obtained; but the result is the same if weakness or disease renders them unable to reach it, although it may be plentiful around them. For while the death-beds of men are usually soothed by the kindness of the friends who moisten the parched lips and administer such nourishment as the sufferer can take, animals dying from old age, weakness, or disease have no such alleviations to their sufferings. The experiments of Chossat on starvation are generally quoted as the most cruel ever performed in a physiological laboratory, and yet they were only repetitions, on an exceedingly small scale, of the experiments which are constantly being performed by the conditions of life on thousands or millions of wild animals throughout the world. The animals on which Chossat experimented did not suffer more pain than those which die in the fields or forests because their death was witnessed by an observer who utilised it to gain knowledge of great importance to man, while the sufferings of their wild companions were unseen by any human eye. Yet many people seem to think that this is the case, and that the mere fact that pain is inflicted for a beneficial purpose renders it much less endurable than if it were simply inflicted thoughtlessly or in sport. More pain is caused by the whip of a London cab-driver in one day than is inflicted in any physiological laboratory in this country in the course of weeks; and the householder who puts down a pot of phosphorous paste to poison the rats which plague him inflicts upon them a more painful death than any they would be likely to suffer at the hands of a vivisectionist. Within the last few years those who experiment upon animals have been frequently and unjustly abused for their endeavours to gain the knowledge necessary to relieve pain and cure disease. They have, however, followed the example of their great master, Harvey, who held that to "return evil-speaking with evil-speaking" was "unworthy in a philosopher and searcher after truth," and have, like him, believed that they "would do better and more advisedly to meet so many indications of ill-breeding with the light of faithful and conclusive observation." They have, indeed, submitted to legislation which was felt to be unjust, inasmuch as it was directed against abuses which were not shown to exist, and which has already been found to hamper greatly the progress of experimental investigation in this country. Confident in their sense of the necessity for experiment, and feeling assured that ere long every one capable of forming a correct opinion and willing to take the trouble of ascertaining the facts for himself would perceive the necessity, they have remained silent, though assailed, like Harvey, with opprobrious epithets. Now, however, when the opponents of vivisection are exerting all their efforts to render legislation, already sufficiently oppressive, entirely prohibitory, the medical profession has spoken out, and with no uncertain voice, and has declared that experiments upon animals are absolutely necessary. Nor could medical men do otherwise. For no man can practise the medical profession without having occasionally to suffer most acutely on account of the imperfection of his knowledge. Often and often is his heart saddened by his patient's asking, with feeble voice and wistful eye, for the relief which he is powerless to give, and again and again has he to avert his face and to shake his head when, with agonised voices, the friends around the dying sufferer cry to him, "Oh, doctor, can nothing more be done?" He sees his patients dying around him for lack of the knowledge which can only be obtained by experiment, and cannot but demand that the right to perform such experiments should be conceded to those who have qualified themselves for the task. There are those who say that, instead of trying experiments on the lower animals, medical men should experiment upon themselves; but, as Prof. Virchow points out, "Medical men are already more exposed in epidemics of all kinds in the performance of their duties in hospitals, in the country, in their nocturnal visits to the sick, in operations and necropsies, than any other class of the community as a rule; and it requires all the blindness of the animal fanatics to require also of them that they should test on their own bodies the remedial, or poisonous, or indifferent action of unknown substances, or that they should determine the limit of permissible doses by observations made on themselves." Nor is this all. Medical men do make experiments upon themselves, and some have sacrificed their own lives in such experiments. But such a method of observation is open to the objection that the sacrifice is to a great extent useless, as the death of the experimenter deprives him of the opportunity of recording the results of his experiment. Not only has the necessity for experimentation upon animals been clearly pointed out in the addresses delivered at the Congress, but this International Medical Congress itself, the greatest assembly of men qualified to judge in the matter that has ever been held, has expressed its judgment in the resolution passed, without a single dissentient, at its concluding general meeting:—

"That this Congress records its conviction that experiments on living animals have proved of the utmost service to medicine in the past, and are indispensable for its future progress; and accordingly, while strongly deprecating the infliction of unnecessary pain, it is of opinion that, alike in the interests of man and of animals, it is not desirable to restrict competent persons in the performance of such experiments."

THE BIBLE AND SCIENCE

The Bible and Science. By T. Lauder Brunton, M.D., D.Sc., F.R.S., &c. (London: Macmillan and Co., 1881.)

THIS work is in the form of seventeen lectures, which appear to have been delivered before an orthodox audience. Their scope is a wide one, ranging from sketches of ancient Egyptian and Israelitish life to the newest results in biological science. The principal object of the book is professedly that of showing how Darwinism is not antagonistic to Christian belief in general, or to the Mosaic account of creation in particular. But although this is the peg, so to speak, on which the course of lectures is made to hang, occasion is taken to devote the main part of the work to rendering in a plain and popular form an epitome of the leading facts of animal and vegetable morphology. This part of the work is admirably done. Indeed we do not know any writings of this nature better calculated to accomplish their object of making science easy to the general reader; and as the spirit is throughout tender, not to say sympathetic, towards traditional beliefs, the book deserves a large circulation among the always increasing class of persons who desire to learn, with a small amount of trouble and without fear of stumbling upon any cloven hoof, what biological science has done, is doing, and is likely to do. In a word, this part of the book, besides being written in a very graceful style, well exemplifies the truth that no writer is so able to serve up to the general public the facts of science in a palatable form as one who is himself a practical worker in the subjects which he expounds. In the interests of scientific education, therefore, we should like to see "The Bible and Science" pass through any number of editions.

Coming now to what is professedly the main object of the work, opinions of course will differ as to the success which has attended Dr. Brunton's efforts. And here it may be observed, first of all, that it is not very clear what the author himself thinks about the deeper topics that underlie his expositions. Apparently addressing an audience of the straitest sect, he judiciously steers clear of all topics save the one immediately before him, *i.e.* showing that the doctrine of evolution is not incompatible with that of the Mosaic cosmology; and although this is perhaps more effectively done than by many previous essayists, there is nothing to show that he is not adopting the method of St. Paul, which he commends, who "graduated his instructions to the people whom he was addressing, first giving them milk, and afterwards strong meat" (p. 358). Of course in this there is nothing to find fault. Because a man sticks to a text which does not happen to contain a confession of faith, we have no reason to object that he does not publish his religious opinions; only we think it well to point out that such is here the case, for any reader who is careless or obtuse might fail to perceive the adroitness with which Dr. Brunton steers his discussion among the rocks of dogma. At every point where we feel inclined to ask what our author himself believes, we virtually fall into a dialogue with him such as that with which is told of another eminent man—"What is your own creed?" "The creed of all sensible men." "And what is that?" "Sensible men never say."

But whatever Dr. Brunton's creed may be, his book everywhere breathes with such a genuine, and indeed we may say pathetic, appreciation of the beauty of the biblical writings and the nobility of religious belief, that if he fails to strike a chord which through all changes and chances is ever ready to vibrate deep down in the bass of human nature, we have only to commiserate the reader who has departed so far from the best and the purest of human emotions. Having travelled through Palestine, and knowing his Bible as thoroughly as his science, Dr. Brunton gives us some beautiful little sketches of Bible scenes, lighted up by numberless interesting suggestions derived from modern science, as well as by the glow of a singularly vivid imagination. Take, for instance, the following:—

"Never in my life do I remember a pleasanter moment than when I sat down on one of these, and looked at the scene before me, for this was the realisation of my childhood's dream; this was the spot where Joseph had lived. Yonder might have been the granaries where he received his brothers; here, in the neighbourhood, stood his house, where he returned, weary of his day's work, and was received by his lovely and loving wife Asenath, whose gentle care had obliterated from his mind, not only all the sorrows and trials of his early life, the hatred of his brothers, his slavery in Egypt, his temptations in Potiphar's house, and his long imprisonment in the dungeon, but had almost made him forget his dead mother, the kind old father who had loved him so well, and the little brother Benjamin to whom he had been so deeply attached, so that he called the name of his first-born son Manasseh, 'For God,' said he, 'hath made me forget all my toil, and all my father's house.' . . . Let us, in order to form an idea of the country, suppose Joseph at this time of the year to be starting on a tour of inspection, and let us in thought accompany him.

"He has said farewell to his wife and children. His chariot and horses are at the gate, he springs up, and, accompanied by his attendants, drives onward towards the southern point of the Delta, just where it joins the Nile valley. At first he proceeds amongst shady trees, bounded on either side by fertile gardens; but as he rides on, his path lies through a strip of hard sandy desert, in crossing which the hind legs of one of the horses ridden by his attendants suddenly becomes paralysed, the animal sinks upon its haunches, and the horseman falls backwards. The Cerastes, or horned snake, a little viper only about a foot long, lying concealed in the sand, which it resembles in colour, irritated by the passage of the cavalcade, has bitten the horse's heel. Immediately the poison spreads up the leg, paralysing it, and, when it reaches the spinal cord, paralyses it also, thus destroying the power of both hind legs, and causing them to give way under the weight of the animal. Only within the last year or two have we learned the exact manner in which such a poison as this acts upon the body; but centuries ago its general effect was well known, and no more vivid description of it could be given than that of the dying Jacob, who compared his son Dan to 'an adder in the way, a serpent in the path, biting the horse's heels, so that the rider falleth backwards.'"

In a similarly picturesque manner we are carried through sundry scenes of early Egyptian life, of the bondage of the Israelites, their exodus, wanderings, and conquest of Palestine. In the course of this exposition, which only errs from being too short, several interesting suggestions are made as to the possible origin of the accounts of some of the Pentateuch miracles. Thus, speaking of the plagues, he says:—

"Amongst these was one that used to puzzle me not a little, the plague of 'darkness which might be felt.' Why, thought I, did all the people remain in the dwellings? Why could they not take lanterns with them and move out? But a day which I spent at Port Said showed me what was probably the reason. On waking in the morning it seemed to me that everything had been turned into pea-soup. Above, around, and on every side, was a thick yellow mist, darkening the air like a London fog, but differing from it in this respect, that it was a darkness perceptible; a darkness that might be felt, and painfully felt too, for it was caused by a storm of sand, driven by the wind, and every particle stinging the skin like a needle."

Again, regarding the passage of the Jordan, he writes:—

"One of the puzzles of my childhood's days was to imagine the condition of the waters thus cut off, for I fancied to myself the River Jordan like such streams as I had been accustomed to, flowing through a small channel with level meadows stretching on either side. How then, I thought, did the waters stand up as in a heap? I could picture to myself a steep, glassy wall of water running across the channel itself, but was there likewise a level wall along each bank, or did the waters flow over the meadows on either side? On seeing the Jordan, however, I at once discovered the solution of my childhood's difficulty."

Then, after describing the double channel of the river—

"Within this larger or outer channel, confined by its bank on either side, the waters of the river might become filled up as a heap. Here was an answer to one inquiry of childhood. There were no invisible or glassy walls, indeed, at the sides to prevent the waters from running over the surrounding country. Was there, then, one to draw them up in their channel, and thus to cut them off towards the Dead Sea? or was the dam here simply of earth? On standing at the river's brink, the whole scene appeared to pass before me. The country around is highly volcanic. Earthquakes occur with great frequency, and during such convulsions of nature we know that the relations of land and water become greatly altered. . . . Here, I thought, we have a method by which the Israelites were able to pass over dryshod. If the bed of the stream at this place underwent a sudden upheaval at the time of their passage, the consequences would be exactly those which are described in the Book of Joshua. The waters would rise up like a heap, filling the channel far up the valley, and those flowing down to the Dead Sea would be cut off.

"To some this explanation may seem mere fancy, but it appears to be the one accepted by the psalmist, for in the 114th Psalm we find, 'Jordan was driven back. The mountains skipped like rams, and the little hills like lambs. What ailed thee, O thou sea, that thou fleddest? thou Jordan, that thou wast driven back? Ye mountains, that ye skipped like rams; and ye little hills, like lambs? Tremble, thou earth, at the presence of the Lord, at the presence of the God of Jacob.' Here the psalmist seems to ask the question why Jordan was driven back, and to give us indirectly as an answer that the earth trembled, or, in other words, that there was an earthquake."

Dr. Brunton seems rather fond of this naturalistic or rationalistic method of explaining the miraculous element in the Old Testament records; but it is evident that the method only serves to let in miracles at the back-door instead of at the front. In this case, for instance, we cannot suppose Joshua to have known that an earthquake was about to take place, or, if he did, that its effect would be to divert the course of the river in the way that Dr. Brunton imagines. (There is a possibility, however, in the subsequent instance with which Dr. Brunton deals, of Joshua commanding the sun and moon to stand still, or become "dumb," that he expected an eclipse, and made good capital of his knowledge.) Therefore we must attribute the occurrence of the earthquake at the moment when the tribes were ready to pass over the river as due to a lucky coincidence which in itself would have been little short of miraculous. And the multiplication of such coincidences that would be required to explain all the Pentateuch miracles by this method would render their occurrence unaccountable save on the hypothesis of a designing mind; and this would constitute them miraculous in the sense of being supernatural. Moreover, many of the miracles cannot possibly be met even by the hypothesis of coincidence. Thus the passage through the Red Sea, which is so analogous to the passage through the Jordan, cannot be thus met. Here no earthquake could have produced the effect described, and if we accept the record as history we are compelled to "imagine the waters standing up as in a heap," with all the difficulty of "picturing a steep, glassy wall of water," &c. We therefore question whether the theory which led, as Dr. Brunton tells us, to the "puzzles" of his "childhood's days," was really more beset with "difficulty" than the one whereby he now endeavours to make his "Bible" square with his "Science." Better swallow miracles in the lump, and so obtain at least consistency, than try to save the historical accuracy of the Pentateuch by playing hide-and-seek with scientific principles, with the result of always losing the game.

The closing chapters of the book are occupied with an endeavour to make evolution acceptable to the orthodox mind. Here we wonder that no mention is made of the circumstance that the order in which the flora and fauna are said by the Mosaic account to have appeared upon the earth corresponds with that which the theory of evolution requires and the evidence of geology proves. On the other hand there are some original ideas which may be found of use among Churchmen of Broad Church proclivities. Thus, after quoting Milton's account of Adam and Eve in Paradise, Dr. Brunton says:—

"This is a very beautiful picture, but it is not at all the one given in Genesis, for there we find that man, after the fall, was a being in the condition of savages of the Stone Age of Europe, clad in skins, and tilling the ground with implements of wood or stone, the use of metals being unknown till generations afterwards. And yet this being, low in the scale as we would term him, is represented as being so much higher in wisdom than Adam before the fall, that he was reckoned almost as a God in comparison, for in Genesis iii. 22, we read that 'The Lord said Behold! the man is become as one of us, to know good and evil.' So that while the Miltonic account of primitive man is an absolute contradiction of the notions of evolution, the Mosaic account is in conformity with them."

Obviously, enough allowance is not here made for what Mr. Darwin would call the "changed conditions of life" which befell Adam and Eve on being turned out of Paradise; the curse so materially altered their "environment" that, as our other apostle of evolution would say, they were no longer "in harmony" with it. Surely, then, Milton was right in representing Adam and Eve in Paradise, not as worse than "savages of the Stone Age of Europe," but rather as a happy and innocent pair living in the midst of plenty, and having access to certain trees which presented physiological properties of so remarkable a character that we greatly wish Dr. Brunton, with his well-known ability in this line of inquiry, could find an opportunity of making them the subject of his next experimental research.

Less open to criticism is the following:—

"Now it is very remarkable that the doctrine of evolution, be it true or no, exactly agrees with the Mosaic account in reference to the place where man was created, whether this creation took place by special act or by evolutionary process. It took place in a paradise, where the air was balmy, where fruit-trees were plentiful, and where there were no carnivorous animals to prey upon and attack man. For man differs from the lower animals in the absence of a furry or hairy coat (although, curiously enough, such a coat is possessed by unborn children). Now, if for a moment we suppose ourselves driven to conclude that, in respect of his physical nature, man was evolved from a lower type of life, he could not have lost his hairy coat unless the air had been soft and balmy; for the essence of the doctrine is that the fittest only survive, and the fittest to survive exposure to heat or cold would not have been the naked, but the hairy individuals. Had not food been abundant and easily masticated, like the fruit of trees, man would not have lost the projecting muzzle and larger jaws of the apes, as a small jaw would be less fitted for the mastication of hard and innutritious food. Had man been liable to the attacks of wild beasts in this paradise, he could not have lost the large canines which form such powerful implements of defence in the gorilla. Nor would he have remained so long helpless, and unable to take care of himself, unless in such a paradise as we have supposed, where all the conditions of life were favourable. The children, which were long in developing, would have been at a disadvantage in the struggle for existence; they would have died off; and the progenitors of the human race could never have developed into men.

"The site, too, of the paradise, according to the evolution theory, agrees exactly with that indicated in the Book of Genesis, and, indeed, until I saw a map by Haeckel, the most prominent defender of the evolution theory in Germany, I was puzzled to understand the Mosaic account. It reads thus [see Genesis]. The site thus indicated with the utmost precision by Moses is perhaps the only one upon the surface of the whole earth which fulfils the demands of the doctrine of evolution. For, as we have already seen, according to this doctrine man must have been developed in a genial climate, in a spot where abundance of food existed. Now such a place might perhaps be found in a similar latitude in America, but it is agreed by all evolutionists that man could not possibly have been developed in the new world, because his affinities are altogether with the monkeys of the old world, and not with those of the new. This is the only point, too, from which man could have spread in such a way as would agree with the distribution of races which we now find.

"But man did not always continue to live in this paradise. He was driven out; according to the theory of evolution, he was probably forced to migrate from this sacred spot for the same reason that races have been forced to migrate ever since, namely, want of food due to increasing numbers. These increasing numbers would, first of all, consume the natural fruits of the trees; they would then be forced to till the ground, and, finally, some of them would be obliged to leave altogether. We read in Genesis that the woman was cursed in her conception being multiplied, and that the man was cursed by having to till the ground by the sweat of his brow. While in paradise he was naked, but after he left it he wore coats of skin. He had not yet learnt the use of metals, and his tools and implements must have been those of wood and stone. For, according to Genesis, it was not until several generations afterwards that Tubal-Cain taught men the use of brass and iron.

"However man was formed, then, the Mosaic account corresponds with what we find in the progress of civilisation—the Stone Age precedes that of Bronze and Iron. The paradise whose locality was indicated by Moses has now disappeared beneath the waters of the Indian Ocean. Whether its disappearance was preceded by some great volcanic eruption or not, and whether such an eruption is referred to in the mention of the flaming sword which turned every way, we cannot tell; but we have no indication in Genesis of the submergence of paradise until the time of the Flood, which," in accordance with Hugh Miller's idea, is supposed by our author to have been due to a subsidence of the land.

We have quoted this passage at length, because it serves to suggest that "the grand old legend" may contain in its beautiful allegory more of traditional history than the present age is always inclined to suppose. Enough has now been said to indicate the general nature of "The Bible and Science," although it may be added that it is furnished with an excellent index. It is an entertaining and instructive book, and we wish it all success.

GEORGE J. ROMANES

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.*]

Thought-Reading

BY the courtesy of Dr. G. M. Beard of New York I had the opportunity of witnessing some interesting experiments in artificial trance performed on one of his trained patients, thought-reading being one of the phases exhibited. After his discovering objects in the usual way, I used a fine copper wire about a yard in length. I wound one end round the right hand of the patient (after he was hypnotised) and then placed his wired hand against his forehead. The patient then wandered round the room in an aimless sort of manner, the wire all the time being quite slack, but the moment I attempted, however gently, to increase the tension just sufficient for him to feel it, he instantly moved off along the direction of the wire, like a horse with a rein. I subsequently tried a thicker wire. The patient stood with his face in a direction at right angles to my own; he moved straight towards the table on my left hand, and after oscillating his head sideways as if trying to find some particular spot, he finally brought his forehead slowly but with great accuracy down upon a metal disk about $1\frac{1}{2}$ inches in diameter, and at a distance of about 18 inches from the edge of the table. This was exactly what I had "willed."

The different effects produced by a slack and a stiff copper wire respectively would seem to show, clearly, that the patient cannot acquire the "will" of the operator unless the connection be sufficiently rigid to communicate the involuntary muscular action of the operator, however imperceptible such action may be to the latter himself, who wills what the patient is to do.

GEORGE HENSLOW

A Gun-Signal Recorder

IN the judgment recently delivered by Mr. Mansfield on the stranding of the steamer *Britannic*, he says:—"With respect to the signals from the Hook Tower it is stated that the gunner who discharged the gun—a twenty-four pound gun—commenced firing at 1.50 a.m. on July 4, and continued firing at intervals of ten minutes till 10.10 a.m. He took the time from his watch, as his sandglasses were unserviceable; he had no light but a dark lantern in his gunhouse. Without imputing to him intentional neglect of his duty or wilful misrepresentation, it seems to the Court that he may have been less vigilant and less accurate than men who were keenly awake to the difficulties of their position, and who must have known that the safety of the ship was involved in their taking the time between the signals with scrupulous care. In his unsupported testimony the Court cannot find that the signals from the Hook Tower were fired at regular intervals of ten minutes. Looking at the importance of accuracy between the intervals of the fog-signals, the Court wish to draw attention to the statement of the gunner that he has no relief in his duty, however prolonged it may be; nor do the Court find that there is any check, mechanical or otherwise, on the gunner to insure accurate firing."

The writer would suggest that a simple recording apparatus might be made by means of a clock controlling the movement of a strip of paper, as in the Morse telegraph; this strip being divided by transverse lines into spaces representing minutes and seconds.

A diaphragm of thin sheet iron, caoutchouc, or other suitable material, connected with a metal point as in the phonograph, would then register each explosion of the gun by depressing the point on to the paper strip, and either making a pencil-mark or a perforation. Such an instrument would be a check on the accurate firing of the gun in the station where it was placed, and the production of the strip would do much to remove the uncertainty which appears to have existed in the case above cited.

Liverpool, July 30 A. G. P.

Symbolical Logic

As Mr. Venn appears to be really serious in accusing me of having misquoted him, I may as well give the whole sentence which contains the statement which he says I distorted. The complete sentence is this:—

"Take, for instance, such problems as those of which Prof. Jevons has discussed a sample under the name of Numerical Logic (*Pr. of Science*, p. 169), as any of those which play so large a part in Mr. Macfarlane's volume, or, still more, as those problems in Probability which Boole justly regarded as the crowning triumph of his system."

I certainly thought that in this sentence the last relative pronoun *which* referred to Boole's probability problems in general, but especially to that much discussed problem (sometimes called his "challenge problem") which Boole gave in illustration of what he conceived to be the superiority of his "general method" over the usual methods. It never struck me therefore that Mr. Venn would seriously accuse me of misquoting him because (in order not to inflict upon the readers of NATURE the irrelevant three-quarters of the above sentence) I represented him as saying that Boole "justly regarded *his problems in probability* as the crowning triumph of his system." What then are the problems to which Mr. Venn refers? This, I own, is not a point upon which I have "any claim to call for an answer," but I think it is a point upon which he might courteously condescend to gratify the natural curiosity of many admiring readers of his "Symbolic Logic," who (unlike me, I am afraid) cannot be suspected of any unkind wish to place him in a difficulty.

Boulogne-sur-Mer, August 2 HUGH MCCOLL

Bisected Humble-Bees

AT the end of my garden two magnificent lime-trees grow, on which bees—of specimens of which I herewith send you portions—feed at this time of the year by hundreds—by thousands. What kind of bees are they? But the following are the points on which I should like some information. Every morning I find numbers of them on the ground, helpless, behaving very much like men when they are drunk. What causes this? Next, how comes it to pass that, apparently, these helpless bees all become bisected or trisected as the specimens I send? This morning there are hundreds of portions under the trees. We have a family of "fly-catchers" in the garden—would they do it?

T. MASHEDER

The Grammar School, Ashby-de-la-Zouch, July 29

[The bees are a common species of Bombus (Humble-bees), mostly workers, and mostly bisected at the junction of thorax and abdomen. Perhaps wasps are the culprits, adopting this method in order to rob the bees of their honey-bags. We shall be glad to have information on this point.—ED.]

A New Meter for Electric Currents

IN NATURE, vol. xxiv. pp. 294–5, you notice a new meter for electric currents, giving a description which is fairly correct for a slight sketch, and attributing the invention to Mr. Edison. The invention, however, is not American, but English, and, as the inventor, I think myself entitled to whatever credit this entirely novel system may merit. My patent rights for America have been purchased of me, and the invention will be shortly in use in New York.

JOHN T. SPRAGUE

Birmingham

[Our correspondent is doubtless right in his claim. Nevertheless the invention we referred to in the brief note in question has been recently patented in this country on behalf of Mr. Edison, presumably at a later date than our correspondent's invention. We should be glad if he would kindly furnish us with the date of his English patent. We certainly meant no injustice in publishing the note.—ED.]

A POPULAR ACCOUNT OF CHAMÆLEONS [1]

II.

THE next most interesting of the animal's life processes is its change of colour. Mistakes and exaggerations as to this matter are of very old date. Aristotle believed

[1] Lecture delivered at the Zoological Gardens on July 28, 1881, by St. George Mivart, F.R.S. Continued from p. 312.

the change to be due to the inflation of the body, and we all know that in Gay's fables it is represented as changing from black to green, blue, and white. The truth is the ground colour of the animal may vary from pale yellow to light or dark green, and so from a bluish to a dark leaden colour.

It is often of a general pale yellow tint, especially at night, in the dark and when perfectly dormant. The general colour need not be uniform, but in one region of one colour, and of another colour in another region, and yellow and bluish tints may be so mixed as to produce a green appearance. The colours may also be different on the two sides of the body. Its most ordinary colour resembles that of the bark of trees or that of leaves, but very distinct and very varied markings may appear as spots or stripes of pale gray, or brown, or black, or yellow, and the stripes or series of spots may extend longitudinally or transversely. Moreover the spots may be either close or distant, and round or angular. They may be dark on a light ground, or light on a dark ground. All the changes of colour which take place take place gradually, and the spots which appear, disappear, and re-appear, are not reproduced in the same places with the exception of markings which radiate from the eye, and others on the tail and limbs.

My poor friend, the late Mr. H. N. Turner, jun., remarked[1] of a chamæleon kept by him that its general tint varied from brown or olive to bright green and yellow. When brought from the dark into lamp-light he found that the side next the light changed sooner than the other. The line of prominent tubercles in the middle of the under surface of the body remains constantly white. Mr. Turner's experiments and those of van der Hoeven seem, as was to be expected, to negative the idea that the animal can assume the colour of surrounding objects.

This faculty of colour change is not really so exceptional a phenomenon as many persons suppose. It exists in certain mollusks, and notably in the cuttle-fishes, which rival the chamæleon in their changing tints. It is also found in certain frogs and lizards, especially in the American kind, called *Sphærops*. As to fishes, Dr. Günther tells us[2]: "In many bright-shining fishes—as mackerels, mullets—the colours appear to be brightest in the time intervening between the capture of the fish and its death, a phenomenon clearly due to the pressure of the convulsively-contracted muscles on the chromatophores. External irritation readily excites the chromatophores to expand—a fact unconsciously utilised by fishermen, who, by scaling the red mullet immediately before its death, produce the desired intensity of the red colour of the skin, without which the fish would not be saleable. In trout which are kept alive in dark places, the black chromatophores are expanded, and consequently such specimens are very dark-coloured; when removed to the light they become paler almost instantaneously.

The chamæleon lays eggs, and its manner of doing so has been described by Vallisnieri, who carefully observed the actions of a female in his possession. She wandered about on the floor of her inclosure till she found a place devoid of dust or sand. There she began to scratch, and continued scratching for two days, till she excavated a depression four inches wide and six inches deep, in which she deposited thirty eggs. She then carefully covered them up, first with earth, and then with dry leaves and twigs and bits of straw.

There are now fifty known species of chamæleon, and twenty-five of them are distinguished by prominences either on the end or sides of the muzzle, or over the eyes, or on the top of the head, or on the occiput. The first twenty-five of the entire list are devoid of such prominences. Their names and the localities whence they come are as follows:--

[1] *Proc.* Zool. Soc., 1851, p. 203.
[2] See his recent magnificent work on Fishes, p. 183.

(1) *Chamæleo vulgaris* is found in Southern Spain, Northern and Southern Africa, Asia Minor, Arabia, Hindostan, and Ceylon. No other kind of chamæleon has nearly so extensive a range.

(2) The kinds called *C. lævigatus* and (3) *C. affinis* both come from Egypt or Eastern Africa. *C. Senegalensis* (4), *C. gracilis* (5), *C. granulosus* (6), *C. dilepis* (7), *C. anchietæ* (8), and *C. fasciatus* (9), all come from Western Africa. *C. cristatus* (10) and *C. Burchelli* (11) come from Fernando Po. *C. capellis* (12), *C. ventralis* (13), *C. pumilus* (14), *C. namaquensis* (15), *C. melanocephalus* (16), *C. gutturalis* (17), and *C. tæniabronchus* (18), all come from Southern Africa. The kind called *C. tigris* (19) is from the Seychelle Islands; and the two species, *C. cephalolepis* (20) and *C. pollenii* (21), are from the Comoro Islands. *C. verrucosus* (22), with *C. balteatus* (23), *C. lateralis* (24), and *C. campani* (25), are from the great island called Madagascar.

As to each of the next list a word or two must be said.

The form called *C. antimena*[1] (26) is furnished with an outgrowth flattened from above downwards, at the end of the muzzle, which is cartilaginous towards its distal end. *C. Labordi*[2] (27) has a similar process more prolonged and entirely bony. *C. superciliaris*[3] (28) has a triangular prominence over each eye. *C. pardalis*[4] (29) has a nose dilated and toothed on each side in front. In *C. globifer*[5] (30) a globular prominence projects anteriorly from each side of the end of the muzzle. *C. calyptratus*[6] (31) and *C. calcaratus*[7] (32) have each the summit of the head conically produced. In *C. cucullatus*[8] (33) a very prominent flap extends out on each side from the occiput. In *C. gularis*[9] (34) there is also a pair of occipital flaps, and the same is the case in *C. brevicornis*[10] (35), with the addition of a process on the end of the snout, covered with smooth scales. *C. Malthe*[11] (36) has a pair of slightly different occipital flaps with the addition (in the male) of an obtuse nasal prominence, which is grooved above. *C. rhinoceratus*[12] (37) has a single central elongated bony nasal prominence, but no occipital flaps. In *C. minor*[13] (38) the male has two flat, compressed, diverging nasal prominences covered with large scutes. In *C. bifurcus*[14] (39) there is a similar pair of bony processes, and also in *C. Parsoni*[15] (40). In *C. O'Shaughnessi*[16] (41) there are also two divergent, compressed, scute-covered nasal prominences. In *C. gallus*[17] (42) the nose of the male is provided with a single long conical appendage, but it is flexible and covered with short tubercles. It and the preceding twenty species also all come from Madagascar. *C. nasutus*[18] (43), from Eastern Africa, has a similar flexible protuberance. The snout of *C. montium*[19] (44) has two prominences which are veritable nasal horns horizontally projecting forwards from above the nostrils. Each is encased in a finely-annulated sheath. It comes from the Camaroon Mountains. The male of *C. Owenii*[20] (45) has no less than three such sheathed horns, one projecting from the front of each orbit, and the other from the middle of the nose. It is an inhabitant of the Island of Fernando Po. In *C. Melleri*[21] (46) the male has a single, compressed bony prominence, sharp-edged above. It comes from Eastern Africa. *C. monachus*[22] (47) has two large occipital flaps. It is an inhabitant of

[1] See Grandidier, *Ann. des Sc. Nat.*, xiv. 1872.
[2] *L.c.*
[3] *Archiv. du Mus.*, vi. Pl. XXII. Fig. 14.
[4] *L.c.* Fig. 11.
[5] Günther, *P.Z. S.* 1879, p. 149, Pl. XIII.
[6] *Archiv. du Mus*, vi. Pl. XXII. Fig. 1.
[7] Peters, *Monatsber* Berlin, 1869, p. 445.
[8] *P.Z.S.* 1864, p. 746.
[9] Günther, *P. Z. S.*, 1879, p. 149, Pl. XII., Fig. B.
[10] *L.c.* Fig. A; and *Ann. and Mag. of Nat. Hist.*, May, 1881, p. 358.
[11] *P. Z. S.*, 1879, p. 148, Pl. XI.
[12] Gray, *P. Z. S.*, 1864, p. 478.
[13] Günther, *Ann. and Mag. Nat. Hist.*, p. 246, Pl. XIII.
[14] *Arch. du Mus.*, vi Pl. XXII. Fig. 3.
[15] *L c.*, Fig. 12.
[16] *Ann. and Mag. of Nat. Hist.*, p. 357, Pl. XIX.
[17] *Ann and Mag. Nat. Hist.*, p. 315, Pl. XVI. Fig. B.
[18] *Archiv du Mus.*, vi. Pl. XXII. Fig. 4.
[19] Günther, *P. Z. S.*, 1874, p. 442, Pl. LVI.
[20] *Archiv du Mus.*, vi. Pl. XXII. Fig. 10.
[21] Gray, *P. Z. S.*, 1864, p. 478, Pl. XXXII. Fig. 1
[22] *P. Z. S.*, 1864, p. 470, Pl. XXXI.

the Island of Socotra. There are also the occipital flaps in *C. Petersii*[1] (48), from Eastern Africa. The two remaining chamæleons are so distinct from the foregoing that they rank as a distinct genus called *Rhampholeon*, a genus which was instituted by Dr. Günther in 1874. The first of these, *R. spectrum*[2] (49) is from the Camaroons; the second, *R. Kerstenii*[3] (50) is from Eastern Africa. Both agree and remarkably differ from all other chamæleons in having the tail short, it being only one-third the total length, or even less. Though its end is prehensile, its prehensile action must be much less perfect than that of the tails of the preceding forty-eight kinds; but this defect is compensated for by the development of a sharp tooth, or denticle, at the inner side of the base of each claw, which must give it a firmer grip. Moreover in *R. spectrum*, though not in *R. Kerstenii*, the grip is yet further aided by a spine which projects vertically from the inner, or flexor, surface of each finger or toe. In *R. spectrum* each eyebrow is produced into a flexible horn-like prominence. In *R. Kerstenii* two long processes project forwards, one over and in front of either eye.

Thus the geographical distribution of the chamæleons is very remarkable. With the single exception of the common species they are entirely confined to Africa and certain more or less adjacent islands, and exist mainly on the south of the equator. No less than twenty-one out of the fifty kinds are from Madagascar, and of the twenty-five kinds which have been enumerated as having horns or other remarkable processes on the head, no less than seventeen are from the same very interesting island, which is thus the great home of chamæleons generally, and especially of these curiously distinguished kinds. The plate-snouted (*C. antimena* and *C. Labordi*), the bony, double-horned species (*C. minor*, *C. bifurcus*, *C. Parsonii*, and *C. O'Shaughnessii*), and the lofty-helmeted (*C. calyptratus* and *C. calcaratus*) kinds are quite peculiar to Madagascar. Those with occipital lobes are found not only there, but also in Mozambique and the Island of Socotra. The Madagascar single-horned *C. rhinoceratus* is resembled by the East African *C. Melleri* and the flexible-snouted Madagascar form, *C. gallus*, is resembled by the East African *C. nasatus*. The species with true horny sheaths to their horns (*C. montium* and *C. Owenii*) are exclusively West African forms.

Fernando Po possesses three species. Two are from the Camaroons. One is an inhabitant of the Seychelle Islands, and two are from the Comoro Islands between Africa and Madagascar. Apart from the common species three kinds are from Eastern Africa, two from Egypt and Abyssinia, nine from Western Africa, and eight from Southern Africa.

Such are the leading facts with respect to chamæleons considered by themselves. Let us now consider their more significant relations to other animals.

The entire mass of animals of all kinds, from what is commonly called the animal kingdom, in contrast with and in distinction from the vegetable kingdom: this great whole is divided into certain vast groups called sub-kingdoms, and the highest of them, called the vertebrate sub-kingdom (because its members possess a spinal column), comprises ourselves, with all beasts, birds, reptiles, efts, frogs and toads, and fishes. We and beasts constitute what is called a class—the class *Mammalia*. Birds form another class—*Aves*. Reptiles (*i.e.* all tortoises, lizards, serpents, and crocodiles, with certain extinct kinds) together constitute the class *Reptilia*. The efts of all kinds, with all frogs and toads, and some other creatures, living and extinct, form the class *Batrachia*, while all fishes are grouped together in the one class *Pisces*. But these five classes are not equally distinct one from another. Birds and reptiles, batrachians and fishes go together as two sets of classes or provinces. On the province containing birds and reptiles the name *Sauropsida* has been bestowed, while the term *Ichthyopsida* has been used to denote the province which contains both Batrachians and Fishes.

The existing class of reptiles contains four orders:—(1) *Crocodilia* (crocodiles and alligators); (2) *Lacertilia* (lizards); (3) *Ophidia* (serpents); and (4) *Chelonia* (tortoises and turtles).

The order *Lacertilia* is made up of a certain number of large groups, each of which is called a family, which family is again composed of genera, while each genus consists of one, two, few or many species.

The chamæleons, as we have seen, form fifty species arranged in two genera: forty-eight species in the genus *Chamæleo*, and two in the genus *Rampholeon*. These two genera together constitute a family—a family of the order Lacertilia.

Putting aside on this occasion a certain very exceptional genus called *Hatteria*, the families of the order Lacertilia may be enumerated as follows:—the true lizards (*Lacertidæ*); the Scincs (*Scincidæ*); the Chalcidians (*Chalcidæ*); the Iguanians (*Iguanidæ*); the Geckos (*Geckotidæ*): and the Monitors (*Varanidæ*).

From all these families that of the chamæleon differs most widely. It differs from all of these:—(1) in the compressed body raised from the ground by its long limbs; (2) in its tongue; (3) in its eyes; (4) in the shape of its feet; and (5) by the form of the tail. It further differs from the Iguanians, Lacertians, Scincs, and Chalcidians, in that its body is not covered with scales.

There are certain Iguanians which present a slight resemblance to the chamæleons: such are the American *Polychrus*, and still more *Sphærops*, which has the eye covered with a granular eyelid with only a small central aperture, and has an equal facility in changing colour. These, however, are but superficial agreements, and in all essential points *Sphærops* is a true Iguanian, and in no way a chamæleon.

Prof. Parker assures us that while the chamæleon is an animal, the structure of the skull of which is "specialised to the utmost," it is nevertheless in other respects a very low form.

The answer to our question, "What is a chamæleon?" is, then, that it is a very exceptional family of the order *Lacertilia*, an order of the class Reptilian, a class which, together with birds, form the Sauropsidian province of the great vertebrate sub-kingdom of animals.

Can we gain any light as to the mode of origin of chamæleons?

The best light we can obtain as to the origin of existing forms is derived from the fossil remains of creatures nearly allied to them. In this way we have been able pretty clearly to ascertain that hog-like creatures and ruminating animals are diverging offshoots from a much more ancient, common, and intermediate type.

In this way also we have, I think, fair evidence to show that the cats are derived from creatures more or less nearly allied to the existing civets.

But the science of organic fossil remains—palæontology—has only as yet been able (so far as I am aware) to point to one relic which has been supposed to be of chamæleon nature—part of a lower jaw from Eocene deposits in North America. It would be curious if an ancient chamæleon should be discovered to have inhabited a region so distant from the home of the existing kinds as is North America. It would not however be an unparallelled fact, for the existing Old World camel was once a New World form. The true nature however of the fragmentary fossil is very doubtful, and we may therefore say that as yet we have no evidence as to the antiquity of the family. But should the fossil turn out to be really part of the jaw of a chamæleon, it would but tend to show that the group itself existed already in Eocene times; it would

[1] *P. Z. S.*, 1864, p. 470. [2] *P. Z. S.*, 1874, p. 443, Pl. LVII.
[3] Peters in von der Decken's "Reisen," iii. p 12, Table I. Fig 1; see also *Ann. and Mag. of Nat. Hist.*, September, 1880, p. 238.

not throw any light upon the *mode of origin* of that group.

The chamæleons have, as we have seen, their main home in Madagascar. That island is also the main home of another very exceptional group, the exceptional group of beasts called lemurs. But lemurs have much resemblance, though probably no true affinity, with apes, and the apes are a group, even more isolated perhaps than lemurs. It is as yet quite impossible to say from what root the ape order took its origin.

The same thing may be said (and a few weeks ago was said by our president in this room) respecting the cetaceans, the order, that is, of whales and porpoises. The same thing again may be said of that very exceptional order of flying beasts, the bats. The chamæleon family then is only one of many others which have this at present quite isolated character. But if we can obtain no clue as to the chamæleon's origin, can we detect any special or unexpected affinities between it and any other creatures which do not belong to its own class, the class of reptiles?

It is now very generally supposed that birds have been derived from reptiles, and there seem to have been two distinct lines of descent—the ostrich kind of birds, from extinct land reptiles called *Dinosauria* (of which the great *Iguanodon* of the Wealden formation is a type) and the other birds from extinct flying reptiles called *Pterosauria*, which had much analogy with our bats. This double origin (which I advocated ten years ago) has recently been reinforced by investigations of Prof. Vogt with respect to that extinct feathered creature of the Oolite, the *Archeopteryx*, which turns out to have many affinities with the Pterosauria.

Now the chamæleon has no resemblance either to the Dinosaurian or to the Pterosaurian reptiles, and certainly nothing could well be less bird-like in appearance or in habits than the chamæleon. The one only point of resemblance—that between its pincer-like feet and those of the parrots—is but a very incomplete one, as we have already seen. Nevertheless there is one strange and unexpected structural character already noted to which it may be interesting to revert.

In birds the lungs (unlike our own and those of beasts) are not closed bags, but communicate with air-sacs which extend far and wide within the body, and which doubtless facilitate their powers of aërial locomotion. In the most active lizards, which dart so quickly to their shelter that the eye cannot follow them, there is nothing of the kind; neither is there in those little lizards which take such long jumps with the help of their parachute-like wings, that they may be said to flit—lizards called by the absurdly formidable name of "flying dragons;" yet in the chamæleon, in spite of its sluggishness, such sacs are present, and thus render unavailing a character which might otherwise be employed to distinguish all birds from all existing reptiles.

But though neither comparative anatomy nor palæontology yet enables us to speculate profitably on the origin of the chamæleon's family, there is one feature met with in many of the species which tends to shed a certain amount of light on principles of variation, and therefore on that of specific origin generally. I refer to the circumstance that so many kinds of chamæleons develop crests, processes, or horns on the muzzle and over the eyes or on the occiput. These outgrowths are so different one from another that it is impossible to believe that they have arisen by inheritance and descent from any one peculiarity of the kind. Superciliary prominences could not give rise to nasal protuberances, or bony outgrowths to true horn-sheathed excrescences, and none of these could either be the parents or the offspring of occipital flaps.

The phenomenon is parallel to what we find in certain groups of birds, as *e.g.*, the birds of paradise, so many kinds of which develop unusual feathery outgrowths—these outgrowths being often so different in nature that they cannot be supposed to have been derived by inheritance one from another.

In such birds then we must admit (as I have long ago urged) that there exists an innate tendency to unusual outgrowths of feathers of one or another kind, and similarly we must admit that there is extant in the nature or essence of chamæleons a tendency to osseous or horny outgrowths from the head of one or of another kind. It has been suggested that these outgrowths in the males are due to the wayward fancy of female chamæleon taste. And certainly the female chamæleon, with her exceptional power of independently moving her eyes, and so simultaneously considering and accurately comparing the horns and warts of two rival swains, is unusually qualified for making a careful matrimonial choice. Seriously speaking, however, I regard this explanation as quite inadequate.

I have elsewhere[1] given my reasons for considering this explanation to be a mistaken one, but the question is far too wide to discuss to-day, suffice it to say that even if this hypothesis were correct it would but imply the presence of an innate tendency in the female to admire horny and warty prominences of certain varied kinds. The one innate tendency is as mysterious, and when deeply considered as significant as in the other.

But apart from these questions, which, however interesting they may be, are still matters of uncertain speculation, the actual structure and the unquestionable facts of the chamæleon's physiology are, as I trust you will now agree with me in saying, matters of very great interest. They offer fields as yet unexplored for careful observation and experiment. Even the most peculiar and important of all the chamæleon's actions—the emission and retraction of its tongue—are actions which, so far as I know, are not by any means clearly understood. But when to such matters of direct observation or immediate inference we add the problems to the solution of which elaborate reasoning has to be employed—reasoning based on wide knowledge of the structures of animals existing and extinct—it will, I think, be evident that the leisure of a long life might be usefully devoted to obtaining a complete and far-reaching knowledge of the natural history of that exceptional family of Lacertian reptiles, the family of the chamæleons.

THE INTERNATIONAL MEDICAL CONGRESS

THE seventh meeting of the International Medical Congress, which has just been held in London, has been remarkable from many points of view. The sudden growth of the Congress from an assembly of 600 to one of over 3000 members, the truly cosmopolitan character of the gathering, the great scientific activity displayed, the lavish private and public hospitality and marked Royal patronage conferred, have one and all marked out this meeting as a very great event. It has been the largest and most complete assembly of scientific men that this age, and therefore any age, has ever witnessed, and if the results to science should prove to be at all commensurate, it will be a very prominent event in the history of the progress of science.

The many and complicated arrangements have been admirably planned by Mr. MacCormac and his able assistant, Mr. Makins, and they have borne successfully the heavy strain of a larger number of members than was previously expected. The Congress has held six general meetings, at each of which an address has been delivered, and the more special work has been conducted in the fifteen sections among which it has been split up. Sir James Paget, as President, delivered the opening address on Wednesday last, which was characterised by his usual

[1] "Lessons from Nature," Chap. X. (Murray, 1876).

eloquence and scientific ability. He did not confine himself to any one subject, but glanced at the progressive character of science, the need for the work of all varieties of minds, and the aim and purpose of science as applied in the medical arts. On the same afternoon Prof. Virchow discussed the value of pathological experiment in an address displaying the most thorough grasp of his subject and vigour of thought and diction; he attacked the opponents of vivisection for their utter inconsistence, and gave a very weighty protest against their claim to regulate the pursuit of knowledge. The French address was to have been read by Prof. Raynaud of Paris, but his sudden death only a few days before the meeting prevented this arrangement being carried out, and the address he had already prepared was read by his friend, M. Féréol: it dealt with the subject of the right sphere of action, and the influence of scepticism in medicine. On Saturday Dr. Billings gave a masterly address on Medical Literature; his tables showed a most alarming growth in the production of volumes and periodicals during the past ten years, but he was able to give some consolation by the statement that the rate of growth had of late shown some slackening: his wise and witty remarks on book-writing, bibliography, cataloguing, and reference were especially valuable as coming from a man of considerable experience in these matters, and applying equally to all varieties of literature. On Monday, Prof. Volkmann, one of Mr. Lister's most ardent disciples in Germany, gave an address on Modern Surgery, which resolved itself into a review of the progress and results of antiseptic surgery. He was followed by Prof. Pasteur, who in a few moments described his latest experiments, and announced results which promise to have as important effects for useful animals as Jenner's vaccination has for man. The final general meeting was held on Tuesday last, when Prof. Huxley addressed the Congress on the Connection of the Biological Sciences with Medicine, tracing this connection from step to step, and pointing out the necessity for a similar close union in the future. The entertainments during the week have been many and brilliant, including, in addition to many partly private, a soirée at South Kensington Museum, a dinner at the Mansion House, reception at the Guildhall, reception by Earl and Lady Granville, *conversazione* at the College of Surgeons, and informal dinner at the Crystal Palace. Notwithstanding all these diversions the real hard work that has been done every day by the great mass of the members of the Congress has been very great, and this, and the free interchange of ideas in conversation of many workers in the same part of the field of science, must be productive of good, both by its direct effect and by the stimulus to work it must afford. Among the many subjects discussed, the germ theory and its various practical bearings and outcomes, have had a prominent share. In the Surgical section there was a debate on the treatment of wounds, in which it was incidentally raised, and there appeared to be a general consensus of opinion that particulate germs play an all-important part in the production of wound diseases, though there was by no means such agreement as to the best means of treating wounds. In the Pathological section a long and very animated discussion was introduced by Prof. Klebs, who discussed the relations of minute organisms to certain specific diseases. Dr. Charlton Bastian supported his well-known views, and was opposed by Lister, Virchow, Pasteur, Hueter, Cheyne, and Roberts, and it was made abundantly evident that the germ theory of disease has not only established itself firmly in the faith of scientific pathologists, but that its importance is becoming wider and greater with rapid strides. By far the most valuable of all the communications bearing upon this subject was M. Pasteur's account of his recent "vaccination" experiments. He has found that by a special mode of cultivation of the poison of chicken cholera he can obtain an attenuated or weakened virus, and that vaccination with this attenuated virus, which merely causes slight and transient local mischief, protects fowls completely from the most active virus for a certain time, and enables them to resist the disease for a far longer period. He has also demonstrated that the source of the attenuation of the virus is the action of atmospheric oxygen, for it is only when the "germs" are allowed to develop in the presence of abundance of oxygen that the containing fluid becomes less intensely poisonous. A "vaccine" for splenic fever or charbon could not be obtained in this manner, but if the virus be allowed to develop in a solution at a temperature of 42°—43° C., with free exposure to the air, it quickly becomes less active, and ultimately, at the end of a few weeks, dies. Experiments on sheep have shown that vaccination with this "attenuated lymph" protects the animal from the action of the purer and more active poison. But great as will be the value of these researches, even if only applied to the two diseases in question, it is far more important to notice their extreme importance from a scientific point of view. First of all they explain in part the action of oxygen in preventing septic infection, and the inflammatory complications of wounds. But they also excite the hope, and go far towards showing that it is not improbable, that by some special form of cultivation every disease-virus may be thus attenuated and a poison result, which if inoculated will produce only a transient local change, but will protect from the virulent form of the disease as completely as efficient vaccination protects from small-pox. Prof. Pasteur referred to the germ theory of disease as one which has ceased to number the practical triumphs it has won; and every day is giving results to add to its importance and value.

NOTES

Mr. W. H. M. Christie, F.R.S., First Assistant at Greenwich Observatory, has been appointed Astronomer Royal, in succession to Sir George Airy, who retires after holding the office for nearly half-a-century.

On October 17 next, fifty years will have elapsed since Prof. Bunsen, the eminent chemist, received his doctor's diploma from Göttingen University. He, however, intends to absent himself from Heidelberg on the day in question, in order to avoid all congratulations and speech-making.

Mr. W. A. Forbes, B.A, Fellow of St. John's College, Cambridge, Prosector to the Zoological Society, has been appointed Lecturer on Comparative Anatomy at Charing Cross Hospital, *vice* the Rev. J. F. Blake, removed to Nottingham.

The discussion in connection with Mr. Mundella's able statement on the Education Estimates had no special bearing on the teaching of science in elementary schools. Steps are evidently being taken to make elementary education more and more efficient, to give those whose school years are short and precious every opportunity of acquiring a knowledge of things that will be really useful to them in after life. It is clear from the facts and figures, as well as the tone of Mr. Mundella's address, that the education of the country is safe in his hands. In the proposals for the revision of the Code laid on the table of the House are several changes for the better. In infant schools, for example, part of the course provided for is a systematic one of simple lessons on objects and on the phenomena of nature and common life. Among the "Class Subjects" in boys' and girls' schools are Physical Geography and Elementary Science, and among the specific subjects are Mechanics, Animal Physiology, Botany, Principles of Agriculture, and Domestic Economy. This is all in the right direction, and is just what we should expect from an Education Minister like Mr. Mundella.

Mr. Mundella stated on Monday that Prof. Leone Levi has prepared an elaborate report on technical education in Italy, which will be referred to the Royal Commission about to be appointed.

At the Exhibition of Electricity the completion of the English telegraphic department is progressing favourably. The series of solid and compact sounders used in the British service will contrast, not without advantage, with the quadruplex Baudat and other apparatus presented by the French administration. The Italian historical section is full of relics of instruments used by Galvani, Volta, &c. A large number of autographs will be exhibited, among which we may note a letter from Volta to Sir Joseph Banks, then president of the Royal Society. This document is stated to be the first description of the Voltaic battery ever written by its inventor. A small magnet, which Galileo armed with his own hand, is exhibited, as well as another magnet used by the academicians "del Cimento" for their determination of the laws of the variation of the attractive power according to distance. The Academy of Aërostation of Paris exhibits a model of the electro-subtractor, an electrical balloon constructed according to the principles advocated by Dupuy de Lome, and a number of other electrical instruments. M. Jules Godard, a well-known aëronaut, has sent an electrical warner; when the balloon is descending an electrical vibrator is set in operation; when it is ascending another bell rings. This effect is obtained very simply by a valve, which is in equilibrium when the balloon keeps its level, and is moved by a slight wind. The formal opening was to take place yesterday by a visit of the President of the Republic, and the doors will be thrown open to the public to-day, although much remains to be done for the completion of the display, which will be a great success.

The French Government has appointed a Committee, presided over by Rear-Admiral Bourgeois, to study the different applications of electricity to navigation.

The rapid advance of civilisation, it is admitted, has the effect of causing native races more and more to disappear. It is therefore the duty of scientific ethnology to save the little which exists still in its originality from destruction, and to preserve the few authentic fragments of an epoch which threatens to be annihilated. The Anthropological Society of Hamburg has issued an application to all those who have occasion, either by their position or calling, &c., especially to consuls, missionaries, merchants, captains, to enter their notes on little-known countries and their populations on a schedule which the Society will supply. The questions being intentionally short and as few as possible, any further communications on the character of the country, notes on the climate, corrections of the charts and sailing directions, would be thankfully welcomed. A great service would be rendered also by sending ethnographical objects, photographs, models, &c., which will be entrusted to the care of the Ethnological Museum.

From a Report on the means employed in France for protecting the vine from destruction by the Phylloxera, by Mr. C. H. Perceval, H.M. Consul at Bordeaux, we take the following interesting extract:—"The information which I have gathered on this subject, from official and other sources, tends to reduce the methods used to the following three:—firstly, submersion of the vineyard, when practicable; secondly, by employing insecticides; and, thirdly, where the vineyards have been destroyed, by the plantation of American varieties of vines, whose roots offer more resistance to the attack of the insect. M. Armand Lalande, the President of the Chamber of Commerce of Bordeaux, proprietor of extensive vineyards in the Médoc, a gentleman to whom I am much indebted for the information and assistance which he has been kind enough to afford me in drawing up this Report, addressed a meeting of that body held in March last on various topics, and I translate the following from his remarks regarding the Phylloxera:—'The Chamber of Commerce has not ceased to show the extreme importance which it attaches to all the means employable in combating this dreadful scourge. Of the 2,200,000 hectares which composed the vineyards of France, 500,000 are destroyed, 500,000 others are greatly attacked: it is a loss of more than three milliards to the country. The Gironde is one of the departments which has suffered most: one-third of the vineyards are destroyed, another third is badly attacked. We must admit, with sorrow, that the very sources of our commerce and of the well-being of our southern population are most seriously compromised. Still we have great hopes that, by energetic and intelligent efforts, we may be enabled gradually to arrest and repair the evil. For the very important vineyards of the Gironde, where submersion is possible, it is a sure remedy, which is generally employed, and with invariable success. In the cases of vineyards already destroyed, the remedy seems to be, to reconstitute them by planting American vines as stocks for grafting French cuttings on, which plan has been the subject of satisfactory and conclusive experiments for the last few years, especially in Languedoc. Where the vines are not too far gone, a judicious use of sulphur of carbon is a certain means of preservation, and, in most cases, practicable, owing to the moderation of the cost.' He then states that he bases his opinion on astonishing and conclusive results, which he has observed in immense vineyards in Languedoc, and also in others of the Gironde, and proposes that steps may be taken to hold an international congress on Phylloxera here in the autumn." The Congress is to open on September 5. As we intimated last week, another Viticultural Congress meets in Milan next week. Mr. Perceval gives some valuable details on the various methods of treating the disease.

MM. Koch and Klocke, who have continued during the summer of 1880 their interesting observations on the motion of the Morteratsch glacier, publish their results in the eighth volume of the *Proceedings* of the Natural History Society of Freiburg. They have measured each half-hour during a fortnight the motion of a point on the glacier, and this year, as well as during the foregoing year, their results are almost negative, *i.e.* the motion was so slow, and the advance of their signal-stick was so small and often even negative, that nothing can be inferred until now as to the motion of this glacier. Thus observing, for instance, the advance of their signal each half hour, on September 11, from midday to six o'clock in the evening, they find the following figures, in millimetres: 0·5, −0·5, −0·5, 0·5, 0·0, 0·2, −0·2, 0·2, −1·0, 1·3, −1·5, −1·5, the negative figures showing a back movement of the signal. Therefore MM. Koch and Klocke have undertaken a thorough verification of their instruments, and they have arrived at the conclusion that the motion observed cannot be attributed to errors of observation. Besides they have devised a special arrangement for keeping their signal motionless in the ice; they sink into the ice of the glacier a large copper tube which is filled with ice and salt, and covered by a small hill of ice, and only then they adjust their scale on the tube. This signal remaining firm throughout the day in the ice, the theodolite being also motionless, and the probable errors of observation not exceeding 0·3 millimetres, the small observed motions must be attributed, they suppose, to some cause yet unknown.

At a recent preliminary meeting at Fishmongers' Hall it was resolved to hold a public meeting in the above hall on Friday, August 5, to make arrangements for holding an International Fisheries Exhibition in 1883.

Under the superintendence of Mr. Wallace, rector of Inverness High School, several of the scientific societies of Northern Scotland met at Elgin on July 29 and 30. Several papers were read and excursions made to places of interest in the neighbourhood, and the meeting seems to have been altogether satisfactory. Arrangements were made to hold a similar meeting next year at Inverness.

THE Annual Meeting of the British Medical Association was opened on Tuesday at Ryde, Isle of Wight.

ANOTHER smart earthquake shock, not so strong however as the last, was felt at Geneva on Friday morning. Three earthquake shocks were felt on Thursday night at Allevard, near Grenoble. An undulatory shock of earthquake was felt at Agram on July 28 at 11h. 8m. a.m. Its direction was from south-east to north-west, and subterranean noise accompanied it. Earthquakes are also reported from Haiti on July 5 and 7, from St. Vincent June 24 and 25, and from Trinidad on June 29.

THE Annual Report of the Paris Observatory for the year 1880 has just been published by the director, Admiral Mouchez. The chief work of the Observatory was the continuation of the revision of the Catalogue of Stars of Lalande; and of the 30,000 observations which were made by the meridian instruments 28,331 were made for this purpose. Until this is finished, the Observatory cannot undertake any other great work; and a catalogue of 20,000 stars observed two or three times up to the end of 1879 is already prepared. As to the precise determination of positions of the fundamental stars, it is not yet begun, the astronomers being engaged in the study of the errors of instruments. M. Lœwy has continued the study of the flexion of the meridional instruments, and the error for the larger one was found to be about 0·02 mm., that is about one second of arc. But M. Mouchez expresses the fear that this small error will be less than several accidental errors depending upon changes of temperature, upon the movements of the telescope and upon the errors of refraction due to imperfect observations of temperature at various heights. The great equatorial telescope was but little used, mainly because of the difficulties of management of the revolving tower. With the other equatorial telescopes the astronomers of the Observatory continued their work on the ecliptical charts, as well as of Jupiter, of the comets, of several small planets, and of double stars. The great telescope was employed for the first time during last year for photography; the photographs of the moon, not, however, as fine as those of Rutherfurd—will probably be soon much improved; several photographs of double stars, and even of nebulæ, were obtained. The most interesting work in physical astronomy was done by M. Thollon with the spectroscope: one of the protuberances he studied was rather remarkable by its immense length of eight minutes, that is of 300,000 kilometres. Much attention was given to the transmission of time to the clocks of the Observatory itself, of Paris, and of provincial towns. The astronomical museum, which will be opened at the Observatory, will soon be quite finished; it will contain a variety of instruments formerly used by renowned astronomers, numerous photographs of instruments of different observatories, and portraits; as to these last, the Report speaks in high terms of the courtesy of several astronomers in England, who have given all facilities for the execution of portraits from originals in their possession. After mentioning the various works pursued by the astronomers of the Observatory, besides their regular business, the Report speaks of the preparations for the observation of the transit of Venus in 1882. None of the methods employed until now have given quite satisfactory results, and the simple observation by telescope may yield errors of as much as ten and fifteen seconds. The photographs, which it was necessary to enlarge thirty and forty times, do not afford the necessary cleanliness. Thus the Observatory proposes to employ micrometrical measures which will afford a greater degree of accuracy when done by telescopes than those which are taken on photographs.

THE opening of the Période "Electorale" has directed the attention of the French Government to the opportunity of connecting the municipal telegraphic system of Paris with the postal organisation. It will be the work of a few days, and of a few hundred pounds.

FROM a privately issued report on silk cultivation in the Chinese province of Kwangtung, we learn that in the Pakhoi district, on the southern seaboard, wild silkworms are found which feed on the camphor tree, and their silk is utilised in a singular manner. When the caterpillar has attained its full size, and is about to enter the *pupa* state, it is cut open and the silk extracted in a form much resembling catgut. This substance, having undergone a process of hardening, makes excellent fish line, and is generally used for that purpose in the Pakhoi district.

FROM the *Colonies and India* we learn that a thick vein of a peculiar substance, which, according to local chemists, contains 50 per cent. of pure paraffin, has been discovered at Hawkes Bay, New Zealand. It is said to be worth 40*l*. per ton, and to exist in enormous quantities.

THE latest excavations made by order of the Athens Archæological Society at Tanagra, the well-known place in Bœotia whence come the charming terra-cotta figures, have yielded important results. On the northern side of the town, in front of the principal gate, fifteen tombs were discovered which were completely untouched. They contained some sixty clay figures, most of them perfect, and measuring between 10 and 35 centimetres in height. They represent satyrs and women standing and sitting, and one is a group of two figures. Besides these many vessels were found, amongst which some twenty lekythoi (paint and oil phials) with antique-painted ornaments. Unfortunately most of these were broken. One vase which was found in a stone case shows an artistic inscription which designates it as a work of Teisias. We may also mention that fourteen scraping irons were found, and also that in two of the tombs some fifty small terra-cotta ornaments were discovered, most of which were brightly coloured, and some covered with thin gold. The excavations became even more important after April 1. The published report mentions twenty vessels, some broken, ten of which are ornamented with paintings. Two of these are said to be particularly fine. Of the numerous clay figures only eight could be got out in a tolerably perfect condition. Of these two are reported to be the most perfect figures ever found at Tanagra. One represents a winged youth who is about to raise himself into the air; before him is a maiden on her knees, her dress forming an arc above her; the youth holds her by the arms as if he wished to take her along with him in his flight. The other masterpiece is an Aphrodite rising from the sea, diving up out of a shell as it were.

THE additions to the Zoological Society's Gardens during the past week include a Polecat (*Mustela putorius*), British, presented by Mr. H. C. Brooke; two Ground Squirrels (*Xerus getulus*) from West Africa, presented by Dr. W. Hume Hart; a Bateleur Eagle (*Helotarsus ecaudatus*) from Africa, presented by Mr. William Waters; a Black-footed Penguin (*Spheniscus demersus*) from South Africa, presented by Capt. Robinson, R.M.S. *Warwick Castle;* two Black Storks (*Ciconia nigra*), European, presented by Dr. Rudolph Blasius; two Wood Owls (*Syrnium aluco*), European, presented by Mr. H. T. Archer; a Slow worm (*Anguis fragilis* albino), British, presented by Mr. A. Phipson, F.Z.S.; two Green Lizards (*Lacerta viridis*) from the Island of Jersey, presented by Mr. Claud Russell; a Sykes Monkey (*Cercopithecus albigularis*) from East Africa, a Common Chamæleon (*Chamæleon vulgaris*) from North Africa, deposited; an Erxleben's Monkey (*Cercopithecus erxlebeni*) from West Africa, two Egyptian Mastigures (*Uromastix spinipes*) from North Africa, two Aldrovandi's Skinks (*Plestiodon auratus*) from

North-West Africa, two Pantherine Toads (*Bufo pantherinus*) from Tunis, on approval; a Bennett's Wallaby (*Halmaturus bennetti*), born in the Gardens. In the Insectarium may now be seen larvæ of the scarce Swallow-tail Butterfly (*Papilio podalirius*), also those of *Attacus atlas* of various sizes, from ones just hatched to ones nearly full-fed. Other noticeable larvæ are the curiously shaped ones of *Stauropus fagi*, and young ones of the North American *Samia cecropia*. Imagos of *Attacus pernyi* are also emerging, reared from eggs laid in the Insectarium in the earlier part of the summer.

OUR ASTRONOMICAL COLUMN

GOULD'S COMET-OBSERVATIONS ON JUNE 11.—Dr. B. A. Gould, director of the Observatory at Cordoba, has communicated to the *Astronomische Nachrichten* particulars of his experiences while observing the great comet of the present year on the evening of June 11. On that evening, he says, "the comet was found with but little difficulty, although considerably north of the estimated place, being recognisable by its diffuse aspect, elongated form, and large diameter, although it was quite pale in the bright twilight, and the tail could not be seen." He had just obtained a rough determination of its position from the equatorial circles for the purpose of finding and identifying some comparison-star, when he found one in the field. He considered it to be some one of the many bright stars of Orion in the vicinity, which would be readily identified, and hence did not complete the approximate determination with the usual care, nor obtain instrumental readings for the star. This he describes as "only a little fainter than the comet itself, and not very dissimilar in aspect: since, although its apparent diameter was much less than the comet's, it was greatly blurred by the exceptionally thick haze and the mists of the horizon, the zenith distance being nearly 80°, I do not think it would have been below the third magnitude, and could rather believe it to have been as bright as the second." Dr. Gould adds: "Only four comparisons were obtained before the comet passed below the horizon; then on attempting to identify the star, I found it in none of the catalogues."

On the next evening he examined the region without finding any visible star, but Rigel was much brighter than the missing object, and there was no visible object in the vicinity of the comet, which he found nearly three degrees to the northward.

The observations gave the following results:—

1881, June 11, position of the comet from the circles of the equatorial. 10h. 58m. 9s. sidereal time. Right ascension, 5h. 11m. 4s. Decl. − 9° 36′.

The comparisons with the star gave:—(Comet—star.)

Cordoba Sid. T. h. m. s.	Diff. R.A. m. s.	Diff. Decl. R.	
11 8 49	+ 0 49	− 16·40	One revolution
11 11 2·5	49	16·16	of micrometer
11 13 11·0	48	16·17	= 19″·08.
11 14 37·5	48·5	15·87	
11 11 55	+ 0 48·6	− 16·15 (− 5′ 8″·1).	

Thus he deduced for the star's position R.A. 5h. 10m. 16s. Decl. − 9° 30′, where our catalogues have no conspicuous star. In his letter to Prof. Krueger he concludes thus:—

"The whole observation has seemed to me so improbable that I have hesitated a good deal before sending it to you, fearing some gross error in reading the circles. But I have discovered none, and the later determination of the comet's geocentric path will remove all uncertainties of this kind."

On receiving these particulars Prof. Krueger, determined the place of the comet for the time of Dr. Gould's observation, from the elements we published in this column, which were founded upon observations between June 22 and July 1, and finds R.A. 5h. 11m. 15s., Decl. − 9° 32′·0, and thence for the place of the star R.A. 5h. 10m. 26s., Decl. − 9° 26′·9, showing only such differences from the observed place as might be well attributed to uncertainty of observation so near the horizon, and to the corrections which the elements used probably required before the perihelion passage. Prof. Krueger remarks that no known bright star exists in this position, and the star-chart of the Berlin Academy for this region, which was formed by Dr. Schmidt, shows here a great blank. He draws attention also to the significant fact that the observed motion in declination in the interval between the first and last comparisons is much less than that which the comet must have had; the elements would indicate about 45″ or more than 2·3 revolutions of the micrometer-screw, while the observations give only 0·5. Dr. Gould especially remarks upon the resemblance of the object to the comet, and Prof. Krueger suggests whether there could have been "eine Verdoppelung des Cometen in Folge einer Luftspiegelung," or again was a *second comet* observed?

The case is a very interesting one. With elements which must give the comet's place on June 11 within a very few seconds of arc, Prof. Krueger's inferences are fully borne out. Thus for June 11·41962, Greenwich mean time, which corresponds to 11h. 11m. 55s. Cordoba sidereal time, diminished by the time for aberration, the right ascension of the comet is found to have been 5h. 11m. 13·0s., Decl. − 9° 35′ 18″, agreeing closely with Dr. Gould's instrumental place obtained a few minutes earlier, and the differential observations thus give for the apparent position of the star, R.A. 5h. 10m. 24·4s., Decl. − 9° 30′ 10″. There appears to be a misprint or an oversight in Dr. Gould's letter as regards the zenith distance of the comet and neighbouring object at the time of his observations, which would be nearer 85° than 80°.

SCHÄBERLE'S COMET.—The following elements of this comet have been calculated by M. Bigourdan, of the Observatory at Paris, from observations on July 18, 23, and 28:—

Perihelion passage, 1881, August 22·60205, M.T. at Paris.

	° ′ ″	
Longitude of perihelion	334 41 10	M.Eq. 1881·0
,, ascending node	96 48 23	
Inclination	39 56 38	
Log. perihelion distance	9·801788	

Motion—retrograde.

Whence the comet's positions for midnight at Berlin, or about 11h. 6m. G.M.T., will be:—

	R.A. h. m. s.	Decl. ° ′	Log. Distance from Earth.	Sun.
August 11	7 54 0	+52 7·6	9·9307	9·8307
13	8 22 55	52 45·6	9·8973	9·8218
15	8 57 39	52 47·2	9·8638	9·8142
17	9 37 38	51 51·4	9·8317	9·8083
19	10 20 39	49 36·7	9·8031	9·8043
21	11 3 21	+45 49·6	9·7806	9·8020

The comet was within naked eye vision on the morning of July 29, and the intensity of light, according to theory, should increase until August 25, about which time we may look for a pretty conspicuous object. The most favourable period for observation will be during the last ten days of August.

THE CONNECTION OF THE BIOLOGICAL SCIENCES WITH MEDICINE[1]

THE great body of theoretical and practical knowledge which has been accumulated by the labours of some eighty generations, since the dawn of scientific thought in Europe, has no collective English name to which an objection may not be raised; and I use the term "medicine" as that which is least likely to be misunderstood; though, as every one knows, the name is commonly applied, in a narrower sense, to one of the chief divisions of the totality of medical science.

Taken in this broad sense, "medicine" not merely denotes a kind of knowledge; but it comprehends the various applications of that knowledge to the alleviation of the sufferings, the repair of the injuries, and the conservation of the health, of living beings. In fact, the practical aspect of medicine so far dominates over every other, that the "Healing Art" is one of its most widely received synonyms. It is so difficult to think of medicine otherwise than as something which is necessarily connected with curative treatment, that we are apt to forget that there must be, and is, such a thing as a pure science of medicine—a "pathology" which has no more necessary subservience to practical ends than has zoology or botany.

The logical connection between this purely scientific doctrine of disease, or pathology, and ordinary biology, is easily traced. Living matter is characterised by its innate tendency to exhibit a definite series of the morphological and physiological phenomena which constitute organisation and life. Given a certain range of conditions, and these phenomena remain the same, within narrow limits, for each kind of living thing. They

[1] Address at the International Medical Congress. By Prof. T. H. Huxley, LL.D., Secretary to the Royal Society.

furnish the normal and typical characters of the species; and, as such, they are the subject matter of ordinary biology.

Outside the range of these conditions, the normal course of the cycle of vital phenomena is disturbed; abnormal structure makes its appearance, or the proper character and mutual adjustment of the functions cease to be preserved. The extent and the importance of these deviations from the typical life may vary indefinitely. They may have no noticeable influence on the general well-being of the economy, or they may favour it. On the other hand, they may be of such a nature as to impede the activities of the organism, or even to involve its destruction.

In the first case, these perturbations are ranged under the wide and somewhat vague category of "variations"; in the second, they are called lesions, states of poisoning, or diseases; and, as morbid states, they lie within the province of pathology. No sharp line of demarcation can be drawn between the two classes of phenomena. No one can say where anatomical variations end and tumours begin, nor where modification of function, which may at first promote health, passes into disease. All that can be said is, that whatever change of structure or function is hurtful belongs to pathology. Hence it is obvious that pathology is a branch of biology; it is the morphology, the physiology, the distribution, the ætiology of abnormal life.

However obvious this conclusion may be now, it was nowise apparent in the infancy of medicine. For it is a peculiarity of the physical sciences, that they are independent in proportion as they are imperfect; and it is only as they advance that the bonds which really unite them all become apparent. Astronomy had no manifest connection with terrestrial physics before the publication of the "Principia"; that of chemistry with physics is of still more modern revelation; that of physics and chemistry, with physiology, has been stoutly denied within the recollection of most of us, and perhaps still may be.

Or, to take a case which affords a closer parallel with that of medicine. Agriculture has been cultivated from the earliest times; and, from a remote antiquity, men have attained considerable practical skill in the cultivation of the useful plants, and have empirically established many scientific truths concerning the conditions under which they flourish. But it is within the memory of many of us that chemistry on the one hand, and vegetable physiology on the other, attained a stage of development such that they were able to furnish a sound basis for scientific agriculture. Similarly, medicine took its rise in the practical needs of mankind. At first, studied without reference to any other branch of knowledge, it long maintained, indeed still to some extent maintains, that independence. Historically, its connection with the biological sciences has been slowly established, and the full extent and intimacy of that connection are only now beginning to be apparent. I trust I have not been mistaken in supposing that an attempt to give a brief sketch of the steps by which a philosophical necessity has become a historical reality, may not be devoid of interest, possibly of instruction, to the members of this great Congress, profoundly interested as all are in the scientific development of medicine.

The history of medicine is more complete and fuller than that of any other science, except perhaps astronomy; and if we follow back the long record as far as clear evidence lights us, we find ourselves taken to the early stages of the civilisation of Greece. The oldest hospitals were the temples of Æsculapius; to these Asclepeia, always erected on healthy sites, hard by fresh springs and surrounded by shady groves, the sick and the maimed resorted to seek the aid of the god of health. Votive tablets or inscriptions recorded the symptoms, no less than the gratitude, of those who were healed; and, from these primitive clinical records, the half-priestly, half-philosophic, caste of the Asclepiads compiled the data upon which the earliest generalisations of medicine, as an inductive science, were based.

In this state, pathology, like all the inductive sciences at their origin, was merely natural history; it registered the phenomena of disease, classified them, and ventured upon a prognosis, wherever the observation of constant co-existences and sequences, suggested a rational expectation of the like recurrence under similar circumstances.

Further than this, it hardly went. In fact, in the then state of knowledge and in the condition of philosophical speculation at that time, neither the causes of the morbid state, nor the *rationale* of treatment, were likely to be sought for as we seek for them now. The anger of a God was a sufficient reason for the existence of a malady, and a dream ample warranty for therapeutic measures; that a physical phenomenon must needs have a physical cause was not the implied or expressed axiom that it is to us moderns.

The great man, whose name is inseparately connected with the foundation of medicine, Hippocrates, certainly knew very little, indeed practically nothing, of anatomy or physiology; and he would probably have been perplexed, even to imagine the possibility of a connection between the zoological studies of his contemporary, Democritus, and medicine. Nevertheless, in so far as he, and those who worked before and after him, in the same spirit, ascertained, as matters of experience, that a wound, or a luxation, or a fever, presented such and such symptoms, and that the return of the patient to health was facilitated by such and such measures, they established laws of nature, and began the construction of the science of pathology.—All true science begins with empiricism—though all true science is such exactly, in so far as it strives to pass out of the empirical stage into that of the deduction of empirical from more general truths. Thus, it is not wonderful that the early physicians had little or nothing to do with the development of biological science; and, on the other hand, that the early biologists did not much concern themselves with medicine. There is nothing to show that the Asclepiads took any prominent share in the work of founding anatomy, physiology, zoology, and botany. Rather do these seem to have sprung from the early philosophers, who were essentially natural philosophers, animated by the characteristically Greek thirst for knowledge as such. Pythagoras, Alcmeon, Democritus, Diogenes of Apollonia, are all credited with anatomical and physiological investigation; and though Aristotle is said to have belonged to an Asclepiad family, and not improbably owed his taste for anatomical and zoological inquiries to the teachings of his father, the physician Nicomachus, the "Historia Animalium," and the treatise "De Partibus Animalium," are as free from any allusion to medicine, as if they had issued from a modern biological laboratory.

It may be added, that it is not easy to see in what way it could have benefited a physician of Alexander's time to know all that Aristotle knew on these subjects. His human anatomy was too rough to avail much in diagnosis, his physiology was too erroneous to supply data for pathological reasoning. But when the Alexandrian school, with Erasistratus and Herophilus at their head, turned to account the opportunities of studying human structure, afforded to them by the Ptolemies, the value of the large amount of accurate knowledge thus obtained to the surgeon for his operations, and to the physician for his diagnosis of internal disorders, became obvious, and a connection was established between anatomy and medicine, which has ever become closer and closer. Since the revival of learning, surgery, medical diagnosis, and anatomy have gone hand in hand. Morgagni called his great work, "De sedibus et causis morborum per anatomen indagatis," and not only showed the way to search out the localities and the causes of disease by anatomy, but himself travelled wonderfully far upon the road. Bichat, discriminating the grosser constitutents of the organs and parts of the body, one from another, pointed out the direction which modern research must take; until, at length, histology, a science of yesterday, as it seems to many of us, has carried the work of Morgagni as far as the microscope can take us, and has extended the realm of pathological anatomy to the limits of the invisible world.

Thanks to the intimate alliance of morphology with medicine, the natural history of disease has, at the present day, attained a high degree of perfection. Accurate regional anatomy has rendered practicable the exploration of the most hidden parts of the organism, and the determination during life of morbid changes in them; anatomical and histological post-mortem investigations have supplied physicians with a clear basis upon which to rest the classification of diseases, and with unerring tests of the accuracy or inaccuracy of their diagnoses.

If men could be satisfied with pure knowledge, the extreme precision with which, in these days, a sufferer may be told what is happening and what is likely to happen, even in the most recondite parts of his bodily frame, should be as satisfactory to the patient, as it is to the scientific pathologist who gives him the information. But I am afraid it is not; and even the practising physician, while no wise underestimating the regulative value of accurate diagnosis, must often lament that so much of his knowledge rather prevents him from doing wrong, than helps him to do right.

A scorner of physic once said that nature and disease may be compared to two men fighting, the doctor to a blind man with a club, who strikes into the *mêlée*, sometimes hitting the disease, and sometimes hitting nature. The matter is not mended if you suppose the blind man's hearing to be so acute that he can register every stage of the struggle and pretty clearly predict how it will end. He had better not meddle at all, until his eyes are opened—until he can see the exact position of the antagonists, and make sure of the effect of his blows. But that which it behoves the physician to see, not indeed with his bodily eye, but with clear intellectual vision, is a process, and the chain of causation involved in that process. Disease, as we have seen, is a perturbation of the normal activities of a living body; and it is, and must remain, unintelligible, so long as we are ignorant of the nature of these normal activities.—In other words, there could be no real science of pathology, until the science of physiology had reached a degree of perfection unattained, and indeed unattainable, until quite recent times.

So far as medicine is concerned, I am not sure that physiology, such as it was down to the time of Harvey, might as well not have existed. Nay, it is perhaps no exaggeration to say, that within the memory of living men, justly renowned practitioners of medicine and surgery knew less physiology than is now to be learned from the most elementary text-book; and, beyond a few broad facts, regarded what they did know, as of extremely little practical importance. Nor am I disposed to blame them for this conclusion; physiology must be useless, or worse than useless, to pathology, so long as its fundamental conceptions are erroneous.

Harvey is often said to be the founder of modern physiology; and there can be no question that the elucidations of the function of the heart, of the nature of the pulse, and of the course of the blood, put forth in the ever-memorable little essay "De motu cordis," directly worked a revolution in men's views of the nature and of the concatenation of some of the most important physiological processes among the higher animals; while, indirectly, their influence was perhaps even more remarkable.

But, though Harvey made this signal and perennially important contribution to the physiology of the moderns, his general conception of vital processes was essentially identical with that of the ancients; and, in the "Exercitationes de generatione," and notably in the singular chapter "De calido innato," he shows himself a true son of Galen and of Aristotle.

For Harvey, the blood possesses powers superior to those of the elements; it is the seat of a soul which is not only vegetative, but also, sensitive and motor. The blood maintains and fashions all parts of the body, "idque summâ cum providentiâ et intellectu in finem certum agens, quasi ratiocinio quodam uteretur."

Here is the doctrine of the "pneuma," the product of the philosophical mould into which the animism of primitive men ran in Greece, in full force. Nor did its strength abate for long after Harvey's time. The same ingrained tendency of the human mind to suppose that a process is explained when it is ascribed to a power of which nothing is known except that it is the hypothetical agent of the process, gave rise in the next century to the animism of Stahl; and, later, to the doctrine of a vital principle, that "asylum ignorantiæ" of physiologists, which has so easily accounted for everything and explained nothing, down to our own times.

Now the essence of modern, as contrasted with ancient, physiological science, appears to me to lie in its antagonism to animistic hypotheses and animistic phraseology. It offers physical explanations of vital phenomena, or frankly confesses that it has none to offer. And so far as I know, the first person who gave expression to this modern view of physiology, who was bold enough to enunciate the proposition that vital phenomena, like all the other phenomena of the physical world, are, in ultimate analysis, resolvable into matter and motion, was René Descartes.

The fifty-four years of life of this most original and powerful thinker are widely overlapped, on both sides, by the eighty of Harvey, who survived his younger contemporary by seven years, and takes pleasure in acknowledging the French philosopher's appreciation of his great discovery.

In fact, Descartes accepted the doctrine of the circulation as propounded by "Hervæus, médecin d'Angleterre," and gave a full account of it in his first work, the famous "Discours de la Méthode," which was published in 1637, only nine years after the exercitation "De motu cordis"; and, though differing from Harvey in some important points (in which it may be noted, in passing, Descartes was wrong and Harvey right), he always speaks of him with great respect. And so important does the subject seem to Descartes, that he returns to it in the "Traité des Passions," and in the "Traité de l'Homme."

It is easy to see that Harvey's work must have had a peculiar significance for the subtle thinker, to whom we owe both the spiritualistic and the materialistic philosophies of modern times. It was in the very year of its publication, 1628, that Descartes withdrew into that life of solitary investigation and meditation of which his philosophy was the fruit. And, as the course of his speculations led him to establish an absolute distinction of nature between the material and the mental worlds, he was logically compelled to seek for the explanation of the phenomena of the material world within itself; and having allotted the realm of thought to the soul, to see nothing but extension and motion in the rest of nature. Descartes uses "thought" as the equivalent of our modern term "consciousness." Thought is the function of the soul, and its only function. Our natural heat and all the movements of the body, says he, do not depend on the soul. Death does not take place from any fault of the soul, but only because some of the principal parts of the body become corrupted. The body of a living man differs from that of a dead man in the same way as a watch or other automaton (that is to say a machine which moves of itself) when it is wound up and has in itself the physical principle of the movements which the mechanism is adapted to perform, differs from the same watch, or other machine, when it is broken and the physical principle of its movement no longer exists. All the actions which are common to us and the lower animals depend only on the conformation of our organs and the course which the animal spirits take in the brain, the nerves, and the muscles; in the same way as the movement of a watch is produced by nothing but the force of its spring and the figure of its wheels and other parts.

Descartes' Treatise on Man is a sketch of human physiology in which a bold attempt is made to explain all the phenomena of life, except those of consciousness, by physical reasonings. To a mind turned in this direction, Harvey's exposition of the heart and vessels as a hydraulic mechanism must have been supremely welcome.

Descartes was not a mere philosophical theorist, but a hard-working dissector and experimenter, and he held the strongest opinion respecting the practical value of the new conception which he was introducing. He speaks of the importance of preserving health, and of the dependence of the mind on the body being so close that perhaps the only way of making men wiser and better than they are, is to be sought in medical science. "It is true," says he, "that as medicine is now practised, it contains little that is very useful; but without any desire to depreciate, I am sure that there is no one, even among professional men, who will not declare that all we know is very little as compared with that which remains to be known; and that we might escape an infinity of diseases of the mind, no less than of the body, and even perhaps from the weakness of old age, if we had sufficient knowledge of their causes, and of all the remedies with which nature has provided us."[1] So strongly impressed was Descartes with this, that he resolved to spend the rest of his life in trying to acquire such a knowledge of nature as would lead to the construction of a better medical doctrine.[2] The anti-Cartesians found material for cheap ridicule in these aspirations of the philosopher: and it is almost needless to say that, in the thirteen years which elapsed between the publication of the "Discours" and the death of Descartes, he did not contribute much to their realisation. But, for the next century, all progress in physiology took place along the lines which Descartes laid down.

The greatest physiological and pathological work of the seventeenth century, Borelli's treatise "De motu animalium," is, to all intents and purposes, a development of Descartes' fundamental conception; and the same may be said of the physiology and pathology of Boerhaave, whose authority dominated in the medical world of the first half of the eighteenth century.

With the origin of modern chemistry, and of electrical science, in the latter half of the eighteenth century, aids in the analysis of the phenomena of life, of which Descartes could not have dreamed, were offered to the physiologist. And the greater part of the gigantic progress which has been made in the present century, is a justification of the prevision of Descartes. For it consists, essentially, in a more and more complete resolution of the grosser organs of the living body into physico-chemical mechanisms.

[1] "Discours de la Méthode," 6e partie, Ed. Cousin, p. 193.
[2] *Ibid.* pp. 193 and 211.

"I shall try to explain our whole bodily machinery in such a way, that it will be no more necessary for us to suppose that the soul produces such movements as are not voluntary, than it is to think that there is in a clock a soul which causes it to show the hours."[1] These words of Descartes might be appropriately taken as a motto by the author of any modern treatise on physiology.

But though, as I think, there is no doubt that Descartes was the first to propound the fundamental conception of the living body as a physical mechanism, which is the distinctive feature of modern, as contrasted with ancient physiology, he was misled by the natural temptation to carry out, in all its details, a parallel between the machines with which he was familiar, such as clocks and pieces of hydraulic apparatus, and the living machine. In all such machines there is a central source of power, and the parts of the machine are merely passive distributors of that power. The Cartesian school conceived of the living body as a machine of this kind; and herein they might have learned from Galen, who, whatever ill use he may have made of the doctrine of "natural faculties," nevertheless had the great merit of perceiving that local forces play a great part in physiology.

The same truth was recognised by Glisson, but it was first prominently brought forward in the Hallerian doctrine of the "vis insita" of muscles. If muscle can contract without nerve, there is an end of the Cartesian mechanical explanation of its contraction by the influx of animal spirits.

The discoveries of Trembley tended in the same direction. In the freshwater *Hydra*, no trace was to be found of that complicated machinery upon which the performance of the functions in the higher animals was supposed to depend. And yet the hydra moved, fed, grew, multiplied, and its fragments exhibited all the powers of the whole. And, finally, the work of Caspar F. Wolff,[2] by demonstrating the fact that the growth and development of both plants and animals take place antecedently to the existence of their grosser organs, and are, in fact, the causes and not the consequences of organisation (as then understood), sapped the foundations of the Cartesian physiology as a complete expression of vital phenomena.

For Wolff, the physical basis of life is a fluid, possessed of a "vis essentialis" and a "solidescibilitas," in virtue of which it gives rise to organisation; and, as he points out, this conclusion strikes at the root of the whole iatro-mechanical system.

In this country, the great authority of John Hunter exerted a similar influence; though it must be admitted that the two sibylline utterances which are the outcome of Hunter's struggles to define his conceptions are often susceptible of more than one interpretation. Nevertheless, on some points, Hunter is clear enough. For example, he is of opinion that "Spirit is only a property of matter" ("Introduction to Natural History," p. 6), he is prepared to renounce animism (*l.c.* p. 8), and his conception of life is so completely physical that he thinks of it as something which can exist in a state of combination in the food. "The aliment we take in has in it, in a fixed state, the real life; and this does not become active until it has got into the lungs; for there it is freed from its prison" ("Observations on Physiology," p. 113). He also thinks that "It is more in accord with the general principles of the animal machine to suppose that none of its effects are produced from any mechanical principle whatever; and that every effect is produced from an action in the part; which action is produced by a stimulus upon the part which acts, or upon some other part with which this part sympathises so as to take up the whole action" (*l.c.* p. 152).

And Hunter is as clear as Wolff, with whose work he was probably unacquainted, that "whatever life is, it most certainly does not depend upon structure or organisation" (*l.c.* p. 114).

Of course it is impossible that Hunter could have intended to deny the existence of purely mechanical operations in the animal body. But while, with Borelli and Boerhaave, he looked upon absorption, nutrition, and secretion, as operations effected by means of the small vessels; he differed from the mechanical physiologists, who regarded these operations as the result of the mechanical properties of the small vessels, such as the size, form, and disposition of their canals and apertures. Hunter, on the contrary, considers them to be the effect of properties of these vessels which are not mechanical but vital. "The vessels," says he, "have more of the polypus in them than any other part of the body," and he talks of the "living and sensitive principles of the arteries," and even of the "dispositions or feelings of the arteries." "When the blood is good and genuine the sensations of the arteries, or the dispositions for sensation, are agreeable. . . . It is then they dispose of the blood to the best advantage, increasing the growth of the whole, supplying any losses, keeping up a due succession, &c." (*l. c.* p. 133)

If we follow Hunter's conceptions to their logical issue, the life of one of the higher animals is essentially the sum of the lives of all the vessels, each of which is a sort of physiological unit, answering to a polype; and, as health is the result of the normal "action of the vessels," so is disease an effect of their abnormal action. Hunter thus stands in thought, as in time, midway between Borelli, on the one hand, and Bichat on the other.

The acute founder of general anatomy, in fact, outdoes Hunter in his desire to exclude physical reasonings from the realm of life. Except in the interpretation of the action of the sense organs, he will not allow physics to have anything to do with physiology.

"To apply the physical sciences to physiology is to explain the phenomena of living bodies by the laws of inert bodies. Now this is a false principle, hence all its consequences are marked with the same stamp. Let us leave to chemistry its affinity, to physics, its elasticity and its gravity. Let us invoke for physiology only sensibility and contractility."[1]

Of all the unfortunate dicta of men of eminent ability this seems one of the most unhappy, when we think of what the application of the methods and the data of physics and chemistry has done towards bringing physiology into its present state. It is not too much to say that one half of a modern text-book of physiology consists of applied physics and chemistry; and that it is exactly in the exploration of the phenomena of sensibility and contractility that physics and chemistry have exerted the most potent influence.

Nevertheless, Bichat rendered a solid service to physiological progress by insisting upon the fact that what we call life, in one of the higher animals, is not an indivisible unitary archæus dominating, from its central seat, the parts of the organism, but a compound result of the synthesis of the separate lives of those parts.

"All animals," says he, "are assemblages of different organs, each of which performs its function and concurs, after its fashion, in the preservation of the whole. They are so many special machines in the general machine which constitutes the individual. But each of these special machines is itself compounded of many tissues of very different natures, which in truth constitute the elements of those organs." (*l.c.* lxxix.) "The conception of a proper vitality is applicable only to these simple tissues, and not to the organs themselves." (*l.c.* lxxxiv.)

And Bichat proceeds to make the obvious application of this doctrine of synthetic life, if I may so call it, to pathology. Since diseases are only alterations of vital properties, and the properties of each tissue are distinct from those of the rest, it is evident that the diseases of each tissue must be different from those of the rest. Therefore, in any organ composed of different tissues, one may be diseased and the other remain healthy; and this is what happens in most cases. (*l.c.* lxxxv.)

In a spirit of true prophecy, Bichat says, "we have arrived at an epoch, in which pathological anatomy should start afresh." For as the analysis of the organs had led him to the tissues, as the physiological units of the organism; so, in a succeeding generation, the analysis of the tissues led to the cell as the physiological element of the tissues. The contemporaneous study of development brought out the same result, and the zoologists and botanists exploring the simplest and the lowest forms of animated beings confirmed the great induction of the cell theory. Thus the apparently opposed views, which have been battling with one another ever since the middle of the last century, have proved to be each half the truth.

The proposition of Descartes that the body of a living man is a machine, the actions of which are explicable by the known laws of matter and motion, is unquestionably largely true. But it is also true, that the living body is a synthesis of innumerable physiological elements, each of which may nearly be described, in Wolff's words, as a fluid possessed of a "vis essentialis," and a "solidescibilitas"; or, in modern phrase, as protoplasm susceptible of structural metamorphosis and functional metabolism: and that the only machinery, in the precise sense in which the Cartesian school understood mechanism, is, that which co-ordinates and regulates these physiological units into an organic whole.

[1] "De la Formation du Fœtus."

[2] "Theoria Generationis," 1759.

[1] "Anatomie générale," i. p. liv.

In fact, the body is a machine of the nature of an army, not of that of a watch, or of a hydraulic apparatus. Of this army, each cell is a soldier, an organ a brigade, the central nervous system head-quarters and field telegraph, the alimentary and circulatory system the commissariat. Losses are made good by recruits born in camp, and the life of the individual is a campaign, conducted successfully for a number of years, but with certain defeat in the long run.

The efficacy of an army, at any given moment, depends on the health of the individual soldier, and on the perfection of the machinery by which he is led and brought into action at the proper time; and, therefore, if the analogy holds good, there can be only two kinds of diseases, the one dependent on abnormal states of the physiological units, the other on perturbation of their co-ordinating and alimentative machinery.

Hence, the establishment of the cell theory, in normal biology, was swiftly followed by a "cellular pathology," as its logical counterpart. I need not remind you how great an instrument of investigation, this doctrine has proved in the hands of the man of genius, to whom its development is due; and who would probably be the last to forget that abnormal conditions of the co-ordinative and distributive machinery of the body are no less important factors of disease.

Henceforward, as it appears to me, the connection of medicine with the biological sciences is clearly defined. Pure pathology is that branch of biology which defines the particular perturbation of cell life, or of the co-ordinating machinery, or of both, on which the phenomena of disease depend.

Those who are conversant with the present state of biology will hardly hesitate to admit that the conception of the life of one of the higher animals as the summation of the lives of a cell aggregate, brought into harmonious action by a co-ordinative machinery formed by some of these cells, constitutes a permanent acquisition of physiological science. But the last form of the battle between the animistic and the physical views of life is seen in the contention whether the physical analysis of vital phenomena can be carried beyond this point or not.

There are some to whom living protoplasm is a substance even such as Harvey conceived the blood to be, "summâ cum providentiâ et intellectu in finem certum agens, quasi ratiocinio quodam"; and who look, with as little favour as Bichat did, upon any attempt to apply the principles and the methods of physics and chemistry to the investigation of the vital processes of growth, metabolism, and contractility. They stand upon the ancient ways; only, in accordance with that progress towards democracy which a great political writer has declared to be the fatal characteristic of modern times, they substitute a republic formed by a few billion of "animulæ" for the monarchy of the all pervading "anima."

Others, on the contrary, supported by a robust faith in the universal applicability of the principles laid down by Descartes, and seeing that the actions called "vital" are, so far as we have any means of knowing, nothing but changes of place of particles of matter, look to molecular physics to achieve the analysis of the living protoplasm itself into a molecular mechanism. If there is any truth in the received doctrines of physics, that contrast between living and inert matter, on which Bichat lays so much stress, does not exist. In nature, nothing is at rest, nothing is amorphous; the simplest particle of that which men in their blindness are pleased to call "brute matter" is a vast aggregate of molecular mechanisms, performing complicated movements of immense rapidity and sensitively adjusting themselves to every change in the surrounding world. Living matter differs from other matter in degree and not in kind; the microcosm repeats the macrocosm; and one chain of causation connects the nebulous original of suns and planetary systems with the protoplasmic foundation of life and organisation.

From this point of view, pathology is the analogue of the theory of perturbations in astronomy; and therapeutics resolves itself into the discovery of the means by which a system of forces competent to eliminate any given perturbation may be introduced into the economy. And, as pathology bases itself upon normal physiology, so therapeutics rests upon pharmacology; which is, strictly speaking, a part of the great biological topic of the influence of conditions on the living organism and has no scientific foundation apart from physiology.

It appears to me that there is no more hopeful indication of the progress of medicine towards the ideal of Descartes than is to be derived from a comparison of the state of pharmacology, at the present day, with that which existed forty years ago. If we consider the knowledge positively acquired, in this short time, of the *modus operandi* of urari, of atropia, of physostigmin, of veratria, of casca, of strychnia, of bromide of potassium, of phosphorus, there can surely be no ground for doubting that, sooner or later, the pharmacologist will supply the physician with the means of affecting, in any desired sense, the functions of any physiological element of the body. It will, in short, become possible to introduce into the economy a molecular mechanism which, like a very cunningly contrived torpedo, shall find its way to some particular group of living elements, and cause an explosion among them, leaving the rest untouched.

The search for the explanation of diseased states in modified cell life; the discovery of the important part played by parasitic organisms in the ætiology of disease; the elucidation of the action of medicaments by the methods and the data of experimental physiology; appear to me to be the greatest steps which have ever been made towards the establishment of medicine on a scientific basis. I need hardly say they could not have been made except for the advance of normal biology.

There can be no question then as to the nature or the value of the connection between medicine and the biological sciences. There can be no doubt that the future of Pathology and of Therapeutics, and therefore that of Practical Medicine, depend upon the extent to which those who occupy themselves with these subjects are trained in the methods and impregnated with the fundamental truths of Biology.

And, in conclusion, I venture to suggest that the collective sagacity of this Congress could occupy itself with no more important question than with this: How is medical education to be arranged, so that, without entangling the student in those details of the systematist which are valueless to him, he may be enabled to obtain a firm grasp of the great truths respecting animal and vegetable life, without which, notwithstanding all the progress of scientific medicine, he will still find himself an empiric?

ON THE VALUE OF PATHOLOGICAL EXPERIMENTS[1]

AS reporter on Medical Education at the last International Medical Congress held in Amsterdam, I raised the question how far the experimental method is necessary to instruction; and the result at which I arrived was that the use of this method to its greatest extent, and especially of vivisection, is an indispensable means.[2] In a still higher measure, however, I had to raise into prominence the importance of this method in research; and, in opposition to those who, with constantly increasing vehemence, brought accusations against the experimental investigators on account of the direction and method of their researches, I was able to say, with the lively assent of the numerous members of the Congress, and without one word in contradiction: "All those who attack vivisection as a means of science have not the least idea of the importance of the science, and much less of the importance of this aid to knowledge."

In the two years which have since passed away, the agitation of the opponents has grown both extensive and important in its object. One country after another has been drawn into their net, and international combinations have been formed, in order by united force to obtain greater results. No increase of satisfaction has been produced by the concessions made in 1876 by the legislation in England. The demands have increased: a petition from the new Leipsic Society for the Protection of Animals, dated March 8 of the present year, desired of the German Reichstag the enactment of a law by which "cruelty to animals under the pretext of scientific research" should be punished "with imprisonment for periods of not less than five weeks to two years, and with simultaneous deprivation of civil rights." All, indeed, do not go so far. Many do not demand that all experiments on living animals should be at once suppressed, but that there should be limitations, some demanding more, others less. But even these do not make it secret that this concession is only provisional; and they demand that even the official laboratories of the universities should be placed under

[1] Address given at the International Medical Congress by Rudolf Virchow, M.D., Professor in the University of Berlin. The Editor of the *British Medical Journal* has kindly allowed us to use his translation of Prof. Virchow's address.

[2] Congrès Périodique International des Sciences Médicales, 6 Session, Amsterdam (1879), 1880, p. 146, *Archiv für Pathol. Anat.*, Band lxxxv. Heft 3.

the control of the members of the Society for the Protection of Animals, so that the members may be at liberty to enter the laboratories at any time.

It would be a mischievous delusion to believe that this movement is without prospect of success, and devoid of danger because of its manifest exaggeration. On the contrary, unmistakable signs indicate that it has gained powerful allies, and that there is an increasingly impending danger in many countries that even the State institutions, created expressly for the purpose of experiment, may have the scientific freedom of their methods attacked. So much the more does it seem to be incumbent on the representatives of medical science to defend their position, and to meet international attacks by international weapons. *The most powerful weapon, however, is truth*; and here, above all, *truth founded on competent knowledge*. If we cannot demonstrate our good right before all the world, and come to a mutual agreement on the ground of this right, our cause must henceforth be looked on as a lost one.

The attacks which are directed against us fall, when closely examined, into two categories, according to the principal point. On the one side it is alleged that the experimental method—yea, modern medicine altogether—is materialistic, if not nihilistic, in its ultimate object; that it offends against sentiment, against morals. On the other side it is denied that the introduction of experiments on animals has had any actual use, that medicine has been really promoted thereby, and especially that the cure of diseases has in consequence made any recognisable progress. Even those who admit that there has been some progress, yet believe that just as much information could have been imparted by anatomy alone as by experiments on living animals.

Such objections are not new to one who knows the history of medicine. For hundreds of years, on similar or identical grounds, the dissection of human bodies was impeded, and anatomists were confined to the dissection of dead animals; if, indeed—as was done by Paracelsus, the contemporary of Vesalius—the insulting question were not asked, whether anatomy was of any use at all. The feeling of the masses was raised against the dissection of human bodies; and it is known that, at the commencement of the fourteenth century, the church for the first time gave permission for this to be done, but only under limitations which were still greater than those under which the larger number of our modern opponents would permit vivisection. It was no accident that the period of the reformation in the church first created for the great Vesalius a free field, so that he might test the truth of Galen's traditional dogmata by his own investigation of human bodies, and place true human anatomy in the stead of that anatomy of animals, which had during centuries formed the groundwork of all medical ideas on the internal arrangement of man.

And now, first of all, pathological anatomy—what obstacles it has had to overcome even in the present time! Nothing is more instructive in this respect than the narrative which Wepfer, the celebrated discoverer of the hæmorrhagic nature of ordinary apoplexy, gives of the acts of enmity with which he was persecuted when—it was towards the middle of the seventeenth century—the council of the town of Schaffhausen had allowed him to dissect the bodies of those dying in the hospital. The only reply which he made to those who said to him that it is injurious and disgraceful to soil his hands with blood and sanies, was, that he could cleanse his hands with some water; but that much more disgraceful and injurious is ignorance of anatomical facts, which inflicts on inexperienced physicians and surgeons a disgrace that not the Rhine, not the ocean itself can wash away.[1] Hence the study of anatomy is much rather to be praised, and to be supported by those who exercise the executive power in the State.

In fact, one Government after another has recognised the decided importance of anatomical science. As far as the civilised world extends, so far at the present day are human bodies dissected. Even the laity comprehends that, without the most accurate knowledge of the structure of the human body and of the changes which disease and recovery produce in it, skilled action on the part of the physician is impossible. Any one who can only take a general survey of the history of science, must know that both the greatest epochs of the resuscitation and reformation of medicine commenced with the definite establishment of both the principal branches of human anatomy, and were even essentially brought about thereby. In the sixteenth century it was physiological anatomy which brought about the definitive victory of empiricism over dogmatism, of science over tradition; in the eighteenth century it was pathological anatomy which replaced mysticism by realism, speculation by necropsy, obscure groping and guessing by systematic thought. The opponents indeed spoke of materialism; but Harvey has rightly said: "Sicut sanorum et boni habitas corporum dissectio plurimum ad philosophiam et rectam physiologiam facet, ita corporum morbosorum et cacheticorum inspectio potissimum ad pathologiam philosophicam.[1]

Antiquity had only one time in which a powerful effort was made for the independent development of human anatomy. It was the time of the Alexandrian School, in the third century B.C., when Erasistratus and his companions, under the protection of the Ptolemies, undertook the first regular dissections of human bodies. The school existed only a short time, and yet it caused the first perceptible agitation of the humoral system of pathology. With the more accurate knowledge of the arrangement of the nerves there grew up a new and more powerful generation of solidists; the empirics raised themselves against the dogmatists, and, though again soon enough subdued, they left behind them as a lasting inheritance the consideration that there is a certain limit to human piety, that the right of the individual to the preservation of the integrity of his body is interrupted by death, and that the veil which covers the mystery of life cannot be raised without the forcible destruction of the connection of the several parts of the body. It is this thought which, as finally realised, has brought forth modern medicine. But, eighteen centuries after the Alexandrian School, the impress of the humoral system of pathology still held independent sway in medicine. Of any positive progress in pathology during that long period nothing can be said. For Bacon has excellently said, in his "Novum Organum," "Quæ in Naturâ fundata sunt, crescunt et augentur: quæ autem in opinione, variantur, non augentur." The old humoral pathology was incapable of development, because it was not founded on nature, but on dogmata. From however different origins they had sprung, Galenism combined everywhere with orthodoxy: among the Arabians with Islam, in the west with Christianity; and it required the powerful movement of the Reformation to burst the chains within which antiquated custom and hierarchical schooling had fettered the thoughts even of physicians. From Erasistratus to Vesalius, and at last to Morgagni, is such an immense stride that it cannot remain concealed even from the weakest eye. Not only the outer form, but the whole nature of medicine has been thereby changed. If one follows Vesalius, yea, even Morgagni, in speaking of the humoral pathology as among still-existing things; if I myself am yet obliged to contend against Rokitansky, the last of the pronounced humoral pathologists, it must still not be forgotten that that was no longer the humoral pathology of Galen or Hippocrates. The four "cardinal juices" Paracelsus had already buried; modern medicine recognises only the actual juices which flow in the vessels, and thence penetrate into the tissues. This modern humoral pathology was essentially blood-pathology (hæmatopathology). In name only does it agree with the humoral pathology of the ancients: in reality, it is quite another thing.

But even hæmatopathology is now happily overcome, and indeed, again, through a proper direction of anatomical study. Since the first but very uncertain researches in the territory of so-called general or philosophical anatomy which Bichat began in the commencement of the present century, down to the more and more rapid advances which the present time has made by means of the microscope, in the knowledge of the more minute processes of healthy and diseased life, attention has been constantly more and more turned from the coarser relations of whole regions and organs of the body to the tissues of which those organs are constituted, and to the elements which again are the efficient centres of activity within those tissues. Immediately after Schwann had demonstrated the importance of cells in the development of the tissues, Johannes Müller and John Goodsir made the happiest applications of the new view to pathological processes; and, looking back to a period in which we ourselves have lived, and which embraces little more than a generation of man, we may now say that never before was there a time when a similarly great zeal in research, and a comparable—though only approximately so—progress in science and knowledge, has

[1] Joh. Jac. Wepfer. "Observ. Anat. ex Cadaveribus eorum quos sustulit Apoplexia." Schaffhausii 1658. "Præfatio: Turpior et damnosior rerum anatomicarum ignorantia est, quæ imperitis Medicis et Chirurgis ignominiam parit, quam nec Rhenus, vec Oceanus abluere potest."

[1] "Guil. Harveji Exercit. Anat." ii., "De Motu Cordis et Sanguinis Circulatione." Roterodami, 1671, p. 174.

spread among physicians. The multiplication of the powers of labour, the constantly increasing emulation in researches, the unmistakable increase in the depth of the questions proposed—all these are phenomena of the most gratifying nature; and one would be very ungrateful if he would not acknowledge that these were in a considerable measure to be ascribed to the improvements in the means of instruction and to the multiplication of laboratories.

No one can be more disposed to concede the high value of anatomical studies to the development of medicine, than one who has made it a part of the task of his life to place anatomy and histology in that commanding position in the recognition of his contemporaries which they deserve. Nothing lies further from me than to discourage those who still expect the greatest benefit to the practice of medicine to arise from following out these studies. May indeed the growing youth, who will have to follow us in assuring the progress of medicine, learn from our example how useful it is to lay the true foundation of our science in anatomy. Assuredly much of that which remains dark to us will then be rendered clear.

But we must not allow ourselves to be forced back on this way as the only permissible one. Were the attempt to hinder totally or in great part researches on living animals to become successful, the same procedure which has been now entered on against vivisection would also be commenced against mortisection. There would no longer be societies for the protection of animals, which we see opposed to us, but societies for the protection of human bodies. There would no longer be thunderings against the tormentings of animals, but against the desecration of corpses. Under the standard of humanity, which is just now unfurled even for animals, there would be preached in a still more impressive manner the campaign against the barbarity of medical men. People would appeal to the feeling of the masses—to the mother on behalf of the body of her child, the son on behalf of the dear remains of his parents. It would be proved that the dismembering of human bodies is injurious to morals and opposed to Christianity. It would be shown that the anatomy of man is useless for the treatment of disease; and perhaps there would be found ignorant or timid or egotistical medical men who would come forth as witnesses against science. The mildest of our opponents would perhaps propose to us the compromise that we should again make the dissection of animals the foundation of instruction. In short, we should be thrown back to the time before Mondini, before Erasistratus.

Such thoughts are by no means the productions of an alarmed fancy. The study of history teaches us sufficiently that victorious fanaticism knows no limits. It desires to heap to the full the measure of its victories; and, even when the traders are contented, the irritated masses press on to obtain the whole results. It is indeed not at all necessary for us to go back to antiquity in order to bring before our eyes the condition of such minds. In no country of modern time are there wanting examples which are recognisable by the eye; for, along with the societies against "scientific tormentors of animals," there exist everywhere, but mostly in a more unassuming form, brotherhoods and associations of all kinds which labour most zealously against the scientific examination of dead bodies. It needs only an impassioned and exciting agitation, such as is now going on against the "torture chambers of science," to denounce to popular indignation the dissecting-rooms as places where the youths under instruction are made barbarous. Whoever undertakes, with the same extravagant fancy as is now used in delineating the physiological laboratory, to describe the *post-mortem* examination of a man, or an anatomical theatre, will not fail to have readers who will turn away with horror and amazement at the misdeeds of anatomists.

In vain will an appeal be made to the fact that not one single school of medicine has existed which has, without a fundamental knowledge of anatomy, established lasting advances in the science or the art of healing. The homœopaths and the so-called nature-doctors (*Naturärzte*), who indeed are already on the scene to strengthen the ranks of the anti vivisectors, will step forth and praise their results. Scepticism, which, from time to time grasps about even in medical circles, and which only too easily finds there followers who have in vain called on medical aid for themselves or their belongings—it will scornfully point out how often the physician is powerless against disease. Therapeutics will be thrown aside as useless lumber; and it will be pointed out to us, as is now already done in the petitions of the societies for the protection of animals, that therapy is to be replaced by hygiene, the treatment of individual patients by general measures of public sanitation. And the attempt will then be made to excite the belief that prophylaxis can exist without anatomy or experiments on animals.

In so large an assembly of medical men as this is, a glance at those present teaches in how many special directions the medicine of to-day has gone. Not every one of these directions is in like measure and as constantly in want of all the means of inquiry and scientific preparation, which are indispensable to cure disease as a whole. Hence, from time to time, a perceptible one-sidedness becomes manifest in certain of these special arrangements. One believes in his own sufficiency, and looks with indifference, sometimes with a kind of polite contempt, on the rest of medicine. Even the truly scientific studies are not exempt from such one-sidedness; on the contrary, human pride, the tendency to over-estimation of oneself, prevail more readily in these than in partial disciplines. We ourselves have seen that organic chemistry, by a most partial use of a very moderate store of knowledge, has made the attempt—and indeed not without some temporary result—to prescribe its laws to medicine: and that numerous practical physicians, unmindful of the history of our science, have in fact sought safety in a new kind of iatro-chemistry. Yes, I have a very lively remembrance of the fact that, when I myself was entering on the scientific career, the hope of giving a purely physical aspect to biology was so powerful, that every attempt at morphological study was treated as something antiquated.

We have not allowed ourselves to be prevented by this from carrying on anatomical research with every exertion; and we are now in the happy position of seeing it everywhere acknowledged, that every advance in minute anatomy sees behind it an advance in physiological knowledge. Physiologists themselves are more and more becoming also histologists. No one however must say that physiology is becoming totally dissolved in histology. No attempt must be made to replace one special subject by another. What is necessary to all branches of medical science in general is the *knowledge of life*. But this can as little be attained by a simple external examination of the living as by a partial investigation of the dead. It can be reached by no single study or specialty; it is much rather the collective result of the cultivation of all individual branches of science.

What is to be attained by a mere external examination of the living body has been thoroughly taught by the older medicine. For centuries sick and healthy have been observed with assiduous diligence, and in fact most valuable material has been collected in the most ingenious manner; but, on the whole, no advance has been made beyond "symptoms." What was perceived were the signs of something internal which was not perceived—indeed the possible perception of which was hitherto doubted. Life itself stood as it were outside observation; it was only a subject of speculation. Intellectual formulæ were laid down, spiritualistic or materialistic, according to the general tendency of the mind of the individual or of the time; but all agreed in the conviction, that life itself is a transcendental and metaphysical problem. For the practical physician, knowledge that was founded in fact began with symptomatology; for disease as such was apparently not less transcendental than life itself, whose antitype it constituted.

How has it now come to pass, that symptomatology has entirely lost the high position in which it still stood little less than a generation ago, to such an extent that in most universities it is no more taught as a specialty? Have symptoms no more any importance for the physician? Can a diagnosis be made without a knowledge of symptoms? Certainly not. But, for the scientific physician, the symptoms are no more the expression of a hidden power, recognisable only in its outer workings: he searches for this power itself, and endeavours to find where it is seated, in the hope of exploring even the nature of its seat. Hence, the first question of the pathologist and of the biologist in general is, Where? That is the anatomical question. No matter whether we endeavour to ascertain the place of the disease or of life with the anatomical knife, or only with the eye or the hand; whether we dissect or only observe, the method of investigation is always anatomical. For this reason, the thoroughly logical founder of pathological anatomy named his fundamental book "De Sedibus Morborum"; and hence this book became the starting-point of a movement which, in a few decades, has changed the entire aspect of science.

This change has been carried out to the greatest extent in ophthalmic surgery. Who could limit himself to perceiving that modern ophthalmology has scarcely a single point of similarity with that of the last century? Who contents himself with the symptom of amaurosis? Who despairs of recognising in it the existence of glaucoma? Every ophthalmic surgeon has in his hands the means of studying the thing itself, and not merely its signs. Even the anti-vivisectors acknowledge that ophthalmology is a study that is capable of effecting something. But they forget that every organ of the body is not so favourably placed and arranged for the observation of its inner processes as is the eyeball. Since the wonderful discovery of the ophthalmoscope, anatomical analysis, even without the use of the knife, has become capable of penetrating so far into the individually remote, that we can immediately observe and study by themselves the smallest features of the fundus oculi, even, indeed, its single cells, or groups of cells, just as in an artificial preparation of an eye that has been excised. But it must not be forgotten that long anatomical and physiological studies have been a necessary preliminary to the interpretation of that which is now so easily perceived. The structure, arrangement, and function of each single part had first to be laboriously established before it was possible, by a transitory glance at the altered tissue, to recognise what is especially changed; and no medical man will attain to a true comprehension of the essence of these changes if he have not previously learned to recognise most accurately the anatomical and physiological nature and the possible pathological changes of the individual constituent parts of the eye.

They speak lightly who object to us, that not all the branches of medicine stand on the same height with ophthalmology. That will never be the case. Just as it is easier to explore the sea in its depths than the solid land, so will the most transparent organ of the body always be the most convenient place for medical diagnosis and treatment. While it is possible to observe without difficulty a cysticercus in the hinder part of the retina, one will always be taught to bring a cysticercus of muscle or a trichina in a patient to light by vivisection. Never can it be required that every medical specialty should altogether equal ophthalmology in security of treatment and diagnosis; but any measure of success can only be sought in the use of the ophthalmological method in a corresponding manner in the other special departments. This method, however, is anatomical, or, as it has otherwise been expressed, localising.

With this, we have reached the point which denotes the boundary between ancient and modern medicine. *The principle of modern medicine is localisation.* To those who still constantly ask of what use modern science has been to practical medicine, we can simply point out that every branch of medical practice has accommodated itself to the principle of localisation, not only in pathology, but also in therapeutics, and that thereby the greatest benefit has accrued to the sick. It is quite superfluous to seek out single examples in order to show what profit the new knowledge has brought. Such examples are abundant. But we do not require them, for we can point to the general character of modern medicine. All those studies which already at an earlier period had a natural tendency to localisation, such as special surgery and dermatology, have in this way been raised to their present state of perfection. Those, however, which have retained from the old humoral pathology a tendency to the establishment of generalising formulæ gradually renounce the favourite tradition; and the fact is more and more comprehended, that generalisation in truth is nothing else than *multiplication of foci*, and that the cure of a so-called general disease signifies just as much as the eradication of a single focus. That was in fact a reform in head and limbs; and he who has not grasped it ought not to say that he has consciously followed the progress of science.

The notion of the general validity of the doctrine of the localisation of disease and of the multiplication of foci of disease in the same individual, stands, as was often objected to me in the beginning of my career as a teacher, in strict opposition to the idea of the *unity of disease*, or, as it is expressed in customary language, to the *ens morbi*. My former colleagues still retained large portions of this idea; they believed that the practical physician entered into arbitrary, and therefore dangerous, speculations, when, in the presence of a single case of disease, he assumed the disease to be a plurality. To me it seems rather the reverse; that the physician enters on a fruitless project (*schematismus*), and one dangerous to his patients, if he suppose each individual case of disease to correspond to the opinion of his school or his own private view, and calculate his prognosis and treatment thereby. Meanwhile, these considerations, derived from medical practice, on the *utility* of a certain way of perceiving disease, can lead to no decision as to its *truth*, and yet, at this result only is it possible to arrive. How shall we establish it?

All the world is at one on this point, that disease presupposes life. In a dead body there is no disease. With death, life and disease disappear simultaneously. This consideration led the older physicians to assume disease to be a self-living or even animated essence, which took its place in the body along with the vital principle. Many went so far as to define disease as a combat between two contending principles, the innate life and an intrusive foreign body. But all came back to life as a preliminary condition of disease. The view was first lost in the old Leyden school; from Boerhaave emanated the dogma, which his pupil Gaubius placed at the head of his long-used "Handbook of General Pathology," the first written on the subject: *Morbus est vita præter naturam.* Disease is life itself; or, to speak more correctly, it is a portion of life.

This assumption displaced the unfortunate dualism which had so long dominated medicine; or, at least, it ought to have displaced this dualism between life and disease. If, nevertheless, it has not completely done this, and if more than a century has been required to break up the still constantly existing dissonance, the reason lies in the difficulty of finding a satisfactory conception of life. And here the question must not be passed by, Where has life its special seat? *Ubi sedes vitæ?* John Hunter went back to the ancient view, already expressed in the Mosaic formula: "The life of the body is in its blood." Flourens believed that he had found the seat of life, the *nœud vital*, in the central nervous system, in the medulla oblongata. The one, like the other, found himself obliged to institute experiments on living animals for the investigation of this difficult question. Therewith the experimental method in the more strict sense began to pass into the practice of pathologists. Vivisection became a regular aid to research.

Certainly the consideration that a knowledge of life can only be obtained on the living being was long present. Beyond doubt it was already formed in antiquity. But it is difficult to determine with accuracy the time when it first became practically active. Uncertain statements only on the subject are available. Zacharias Sylvius, a physician of Rotterdam, who wrote the preface to the Dutch edition of Harvey's "Exercitationes," calls to mind the tale of Democritus, whom the Abderites regarded as insane, because they saw him constantly engaged in vivisection; when however the great Hippocrates was sent for to cure him, he fully recognised the value of his proceedings, and declared that all the Abderites were lunatics, and that Democritus alone was sane.[1] Probably this story has been narrated at the expense of the good Abderites; but it still shows that vivisection already "lay in the air." I will not attempt to decide whether it is true that the teachers in the Alexandrian school actually availed themselves of the permission of their king to dissect criminals. The only conclusion which I can derive from these tales is that researches on animals must surely have at that time been already practised. For whoever reflects on the vivisection of men must acknowledge that, especially at a time when the anatomy of animals formed the foundation of medical study, vivisection had certainly been previously done on animals. In the school of the empirics which proceeded from that of Alexandria, and in which necropsy was taught as the chief means of knowledge, experiment also appears as having a recognised claim; in the celebrated formula, which has been called the tripod of the empirics, and which served as the programme of their school, deliberately-planned experiment is expressly mentioned (*φυσικὴ ἢ αὐτοσχεδίη τήρησις*). Only it is not evident to what extent this research on living animals was carried on. Hence it is also unprofitable to inquire what advantage of any kind ancient medicine derived from vivisection.

In fact, the first great and distinctive example of successful vivisection which the history of medicine knows is that of William Harvey. The foundation of the doctrine of the circulation, which in the main was experimental, has radically changed the whole direction of the thoughts of physicians.

[1] "Harveji Exercit. Anat." Roterod., 1671. "Præfatio: Democritus solertissimus operum naturæ perscrutator, cum assidue secandis animalibus occuparetur, existimatus fuit insanus ab Abderitis; qui miserati sortem hominis advocarunt Hippocratem, ut illi medicinam faceret mentemque alienatam restitueret. Rogatus decurrit et offendit Democritum animalia secantem, quo spectaculo mirum in modum oblectatus, omnes Abderitas insanire pronuntiavit, solum sapere Democritum."

Had we this one example alone it would be sufficient to prove brilliantly the utility, yea, the indispensability, of vivisection. Never has a dogma firmly established by the tradition of centuries and every kind of authority, which in truth formed the central point of a powerful and generally acknowledged system, been annihilated with such a headlong downfall. In complete recognition of the importance of such a man, Albert von Haller said that Harvey's name was the second in medicine, that of Hippocrates being the first. But it was a difficult step, to advance a new and unheard-of doctrine which interfered with science in so revolutionary a manner. Having hesitated long whether he should publish his discovery, and when he at last carried his resolution into effect, the great vivisector cried: "Utcumque sit, jam jacta est alea, spes mea in amantium veritatis et doctorum animorum candore sita" (*loc. cit.* p. 81).

It is certainly due, even in the present day, to the purity of a truth-loving and cultivated mind, to exonerate Harvey from the reproach of heartlessness, perhaps of brutality, of which our anti-vivisectionists are so liberal. His new knowledge had cost the lives of many animals; he started, as he himself says, "ex vivorum (experiendi causâ) dissectione, arteriarium apertione disquisitionæque multimoda." And yet that was the least thing with which he was reproached; even kings at that time were so little tender-hearted, or, I may say, with an opponent, were so brutalised, that King Charles I. found pleasure in seeing the experiments of his body-physician.

On the other hand, after Malpighi had, still in the same century, demonstrated the flow of blood in the capillaries of living animals, and after our century has added the knowledge of the existence of an actual capillary wall, the doctrine of the circulation appears so self-evident, it has so thoroughly entered into the ideas of all, that it already requires a peculiarly-trained mind to comprehend the opinion of the older physicians on the local relations of the current of the blood. Whoever goes unprepared to the study of the medical classics, falls from one misunderstanding into another. The ideas of the nature of local processes are entirely changed, and yet the circulation, the capillary certainly more than that of the larger vessels, stands in the foreground of pathological interest almost more than in truth it should. The widely comprehensive doctrine of inflammation and new growth, within which nearly the greater part of practical cases occur, was founded on experiments on the capillary circulation; not less so was the doctrine of the cure of local diseased processes of most varied kinds.

Even the worst opponents of vivisection recognise Harvey's services. But, say they, since then, nothing more of importance has been accomplished by vivisection. They do not know that it is precisely that department of the doctrine of the process of the circulation which embraces the vital properties of the organs of circulation, which is entirely unmentioned by Harvey.

On what does the activity of the heart depend? What influence do the vessels exert on the propulsion and distribution of the blood? What share falls to the arteries, what to the veins, what to the capillaries? All these questions are of the highest practical importance, and none of them can be investigated otherwise than by experiments on animals. But Harvey could not attack these questions, because in his time minute anatomy was not yet developed. Who knew anything of the nerves of the heart, or of the vessels? Who had any notion as to the participation in the manifestations of the action of the heart and blood-vessels, on the part of the nerves, which supply the parietal structures, especially the fine muscles?

An interval of two centuries again intervened before Edward Weber, by experiment on the vagus nerve in a living animal, first revealed the mystery of the innervation of the heart; and this, again, in a quite unexpected and unprecedented manner; and before our now so much abused friend Claude Bernard likewise showed on a living animal the influence of the sympathetic nerve on the vessels of the head and neck.

Now for the first time, and through numerous other experiments which have tended to this end, we understand the circulation in its special characters. The pulse, that so highly treasured object of the old symptomatology, allows itself to be interpreted. It is to us no longer the sign of this or that disease, but the sign of the existence or non-existence of certain activities, of strength or weakness, of irritation or relaxation of certain tissues. Now for the first time we can understand in its individual peculiarities the action of the heart itself and the operation on it of certain substances—*e.g.* cardiac poisons; and it is not almost alone the department of diseases of the valves, to which alone, and with a scorn that cannot be rightly understood, the anti-vivisectors point on account of their incurability, but also the department of febrile diseases, which we are in a position to survey as well with regard to their symptoms as to their nature and their results.

The length of the interval of time between Harvey and the more recent experimenters on the innervation of the vascular apparatus is explained by the circumstance that in that intermediate time two entirely new studies had to be created, to both of which the discovery of the circulation was an impulse and a preliminary condition. I mean physiology and general pathology; thus, indeed, both these studies, which are to be regarded as the chief support of the experimental method, and which it was originally the custom to comprise under the name of "Institutiones Medicæ." Hermann Boerhaave had, in his professorship, combined them, and, indeed, had even united them with practical medicine; under his pupils the division of labour commenced, and the formal separation of the studies. Haller was the special creator of physiology. His experiments went first in the direction of exploring the vital properties of individual parts of the body, of single tissues, as would now be said. Among these properties, following the distinguished Glisson, a man, it seems to me, not even now sufficiently honoured in his country, he assigned a prominent place to irritability. It would lead me too far if I in this place desired to attempt to show forth individually these memorable researches, the comprehension of which was rendered extremely difficult by the then not yet sufficiently complete explanation of the motions "irritability" and "contractility." For our purpose it is sufficient to point out that here for the first time nerve and muscle, the two most highly developed and thereby most energetic portions of the animal body, were made the subjects of experiment with regard to their special forms of activity. Contraction and sensibility appear as the special signs of living activity. Therewith the question of the basis of living activity was so nearly approached that Gaubius, who at the same time laid the foundations of general pathology, indicated the vital force as the source of contraction, without going further.[1]

From these beginnings was developed, at first in a very obscure and equally unprofitable manner, especially clouded by speculative vitalism, the doctrine of life in its modern form. It has required much longer labours, mostly experimental, to arrive at a great and practical result in spite of all deviations. From the conception of irritability, originally created by Glisson, that of contractility has gradually become separate: and the contrast in which Haller placed irritability and sensibility with regard to each other has been dissolved, by the fact that contractility and sensibility are regarded as two special forms of expression of life connected with various elements, and are subordinated to irritability as the general expression. In this sense, irritability and vitality are nearly identical. Both are properties of tissue, and as such directly or indirectly accessible to treatment and experiment.

In fact, experimentation is now rather directed to the tissue itself. Galvani's discovery of electric contractions, the labours of Alexander von Humboldt on irritated muscle and nerve-fibre, and many other contemporaneous researches, afford evidence of the changed direction in which the new biology laboured. More and more sank down the mysticism of the spirits of life and of disease, the speculation as to an individual vital force; and from generation to generation medicine assumed more and more the character of a real natural science. The obscurity which had dominated especially the nervous system, disappeared under the common labours of anatomists and experimenters; and especially since Charles Bell taught the difference of the nerves hitherto considered as similar in nature, and thereby opened the road to research on the special importance and power of the single divisions of the central nervous system, one work after another has appeared, which has diffused new light on this difficult and complicated subject. It is impossible to go through all these works on this occasion, and it would be superfluous in an assembly of such accomplished men, many of whom have themselves laboured in this glorious work.

I will now only briefly point out that among these labours a constantly clearer and more triumphant idea has advanced, which in its beginnings reaches far back into past time—namely, the idea of the proper life (*vita propria*) of the tissues. Every new form of experiment which is devised renders new parts accessible

[1] Gaubius, "Institut. Path. Med.," p. 71. "Vis vitalis solidi est, qua illud ad contactum irritamenti se contrahit."

to scientific examination, and with each step in advance we become more clearly convinced that life, regarded as a great unit in the established sense, is a pure fiction, arising from the observation that in the hierarchical organisation of the human body certain organs attain so elaborate a structure, and therewith so great importance, that they with complete right merit the name of vital organs. And as among these organs the *medulla oblongata* possesses the greatest importance, it is easily comprehensible that the idea should arise that it might really be the seat of life. But we know now that life is a collective functional action of all parts of the higher or vital, as well as of the lower and less important; and that there is no one seat of life, but that every true elementary part, especially every cell, is a seat of life. In biological research, also, as well as in pathological, we have arrived at a multiplication of foci. Of course the number of vital foci is much greater than that of foci of disease can ever be; and hence disease and life, or to speak more accurately, diseased and healthy life, can very well coexist in the same organism; always, however, so that disease signifies a reduction, a *minus* of healthy life. By this research we have even rediscovered the long-lost essence of disease, not indeed in a spiritualistic form, but as a quite material *ens*, a genuine incarnate thing—*the altered cell.*

Has all now produced advantage? Was it worth the trouble to inflict pain on so many animals? to kill so many animals? Is there a really justifiable claim for allowing the experimental method to proceed still further? We can answer all these questions confidently in the affirmative. Not every experiment on animals has results as great as that of Galvani, results which have not merely led to a new and effective method of treating disease—electrotherapy; which have not only disclosed a large new territory of vital processes, but have supplied the first preliminary condition for an incalculable number of the most important technical arrangements, the knowledge of the natural course of events. But galvanism might yet appear to limited and timid heads as an instructive and refreshing play, for the reason that not every result of true observation of nature is usually brought forward at once, and that nevertheless it may be of the highest practical value. The cellular theory and the proof of the *vita propria seu cellularis* are in themselves very abstruse things, and no one can cure patients by their means without understanding something further. And yet they have become the foundation, yea, in a certain measure the security, for localising therapeutics, and they will surely become more so from day to day, when first materia medica in its wider extent shall have gone on the way which toxicology has already for a long time followed in a manner so rich in results.

How then can a great result to the science of healing be expected, if research in animals be cut off? For a long time no remedy has been more rapidly recognised, or more extensively used, than chloral, the effects of which were discovered and established experimentally by Herr O. Liebreich in my laboratory. How would it have been possible to know how to ascertain those effects without experiments on animals? The animals' friends say to us, "Then try the new medicine on yourselves!" They refer us to the provings of medicines by the homœopaths. But, quite independently of the fact that the provings of the homœopaths have not taught us to recognise one single new remedy which can be compared even at a distance with chloral, and that these provings, even in regard to already known remedies, do not in the least correspond to scientific investigations; that thus they cannot be altogether regarded as an original example—one will yet not be able to earnestly desire that very different, possibly poisonous bodies, should be made the subject of self-experimentation by physicians or other men. This kind of morality, which forbids experiments on animals and counsels experiments on one's own life or on sick men, misses, in fact, the first foundations of intelligent examination.

The proof of the great importance of hygiene and prophylaxis is rather superfluous. If any class of men has been active in this direction it is surely medical men. Never has there been a want of zealous hygienists among them; and when a great problem of prophylaxis was to be solved, one might be sure of finding medical men engaged in the work. We are so accustomed to this obligation that we always regard hygiene and prophylaxis as belonging to medicine, and to no other science. But it is empty talk when it is said that prophylaxis will render therapeutics—yea, even in a certain degree, medicine—superfluous. The arrangement of this imperfect world is such that there surely will be sick as long as men exist; and we are not afraid because of the threat that there will be no further need of us. Not even through the assistance of hygiene will people be able to do without us; and still less without experiment on animals. Will even the hygienists be condemned to test the various "causes" cold and warmth, dryness and moisture, dust and noxious gases, micrococci and bacteria, on their own persons, in order that they may from such self-observations determine their effects, and formulate laws? Intelligent Governments will comprehend that it would be an act of madness to sacrifice human life, merely because it occurs to a small number of persons that it is criminal to sacrifice the lives of animals. Medical men are already more exposed in epidemics of all kinds, in the performance of their duties in hospitals, in the country, in their nocturnal visits to the sick, in operations and necropsies, than any other class of the community as a rule; and it requires all the blindness of the animal fanatics to require also of them that they should test on their own bodies the remedial, or poisonous, or indifferent action of unknown substances, or that they should determine the limit of permissible doses by observations made on themselves.

In the name of humanity, of morality, of religion, the suppression of experiment on animals is demanded. For, in fact, it is not merely vivisection that is in question, but experiment on animals; that is, the experimental method in general. When the term vivisection is used it is made to include in like manner all painful actions in which there is no cutting; indeed, to prevent any misconception, not only physiological, but also pathological and pharmacological, experiments, are expressly included. *The criterion is pain. Everything by which, in the way of experiment, pain is inflicted on an animal is torture of animals,* and so far immoral, and contrary to religion. With this definition of torture of animals it might be possible to arrive at exceptional results by applying it to other callings or men. The dog-fanciers, who in the rearing of their dogs often use, or cause to be used, methods full of torture and painful chastisement, would readily come into great danger. The improvement of horses for certain purposes would have to be entirely put down. A great part of our domestic animals would have to remain untrained, so that pain might be spared to them. We should perhaps arrive at conditions similar to those produced by the wild dogs in Turkey.

Individual anti-vivisectors are at least so far consistent that they would see the slaughter of animals also forbidden. From the vegetarian standpoint, the opposition gains a kind of systematic aspect. Thus Herr von Seefeld[1] demands a vegetable diet and the prohibition of vivisectors; but as he, as a vegetarian, has no need of flesh, he is strongly inclined to make still further concessions. Thus he rejects hunting for the purpose of pleasure, but cannot altogether dispense with it as a means of defending life. Others go still further, and sacrifice also war. The principle can scarcely be denied, that death is worse than torture. There could scarcely be a criminal code, which punishes the premeditated killing of a man less severely than the torture of a man. Not without reason is it alleged that a man who still remains alive after his misdeeds may recover and attain to a complete or entire enjoyment of life. Grounds of mitigation in cases of murder and manslaughter are allowed also to men; but, as a foundation, the extremest injury which can be inflicted on man is always and everywhere the most severely punished.

As regards animals, the anti-vivisectors, on the contrary, consider torture to be worse than death. Although they reject every torturing or painful method of death, even for cattle, they without the slightest consideration cause animals, even highly organised ones, to be slaughtered or killed, not only for eating, but also for other purely subjective reasons. They go, indeed, so far as to demand that an animal which has survived vivisection shall be killed, although it might possibly still enjoy a long and happy life. Is there any logic in this, or any morality? How? May we have the right to kill an animal on any ground of public utility, to eat its flesh, to sell its skin, to pound its bones to manure for the field? and are we not to have the right of subjecting it to scientific research, which we institute on entirely ideal grounds, or on the grounds of the public weal, in which we even perhaps run the risk of becoming diseased? It will be difficult to assume that we institute researches on glanders or splenic fever for pleasure, or to pass away time, or without knowledge of the great danger of inoculation. Whoever allows himself the right to kill animals, has no right to forbid physi-

[1] Alfred von Seefeld. "Altes und Neues über die vegetarianische Lebensweise." (Hanover, 1880.)

cians to vivisect animals for experimental purposes, or to undertake painful operations of any other kind.

Of course we cannot desire that the misuse of this right should escape punishment. For it is with such an abuse, not with the production of pain, that torture of animals first comes into operation. Were every production of pain in itself an act of torture, punishment ought to be inflicted on a veterinary surgeon when he operates on a sick horse for the purpose of curing it. Culpable torture of animals lies before us, when pain is inflicted on an animal in a useless manner, and without purpose. Hence nothing can be said against the view that every experimenter should be subject to official inspection; but surely this does not require a society for the protection of animals. He who has a greater interest in domestic animals than in science, that is, in the knowledge of truth, is not qualified to be an official controller of scientific affairs. To what would it lead, if an experimenter, who had commenced his experiment in good faith, had perhaps o answer to some layman during the experiment, or to a magistrate afterwards, the charge that he had not selected some other method, or some other instruments, or perhaps some other experiment?

No: here is no question of objective right. So long as perfect liberty is left to every possessor of animals to kill his animals, be they wild or tame, at any time, and according to his own judgment, so long must it also be permitted that, for scientific ends, and thus on purely internal grounds, experiments should be made on living animals. But the necessity of such experiments can naturally only be decided by the inquirer himself; as to the choice of place, time, the admission of strangers, he may be required to communicate with the inspector; but the carrying out of the experiment must remain in his own hands. So we understand the expression of the freedom of science.

What is objected to us is, that it is the outraged feelings of the possessor of horses, pet dogs, and parlour cats that excite him to the belief that the same thing may happen to his beloved animals as to the animals in the learned institute. We can sympathise with him. We would force no one to deliver to us his favourites, not would we steal them. Were either of the two to occur, probably in every country the intervention of the magistrate would be called on with effect. But we also require that the disposal of the life and maintenance of those animals which have come into our possession in a legitimate way, should not be lessened to us, and that we should not be considered or declared to be *à priori* rough, void of moral feeling, and barbarians standing almost on the threshold of crime. The evidence that moral earnestness is failing in modern medical circles is nowhere afforded. The reproach that Christianity is imperilled by vivisection is worthy of Abdera. The assertion that the medical youth are inevitably "brutalised" by dissection and vivisection is, as usual, snatched from the air; as it is also a calumny that the vivisecting teachers have suffered injury to their morality

At least however there is no ground to fear for science itself. To it is applicable what Bacon said of the sun: "Palatia et cloacas ingreditur, neque tamen polluitur."

SOCIETIES AND ACADEMIES

PARIS

Academy of Sciences, August 1.—M. Jamin in the chair.—The following papers were read:—On the formation of tails of comets (second note), by M. Faye. Herschel, Arago, Delaunay, and other astronomers did not thoroughly study the tails of comets, but Newton had already given a quite sufficient explanation of the phenomena. The tail is nothing else—he maintained—than the result of a continual emission of molecules from the head of the comet. It is very much like the tail of smoke emitted by a running locomotive, its outer end being lost in space, and the inner one continually receiving a new supply of molecules. M. Roche, who has made the necessary calculations, taking account of the repulsive force M. Faye advocates, has worked out all those shapes of tails which we witness in reality.—On the equivalence of quadratic forms, by M. Jordan.—On a modification of the electric lamp, by M. Jamin, being the result of observations on the electric light in vacuum, and in closed vessels containing various gases.—On the perchloric acids, by M. Berthelot—On the travels of Moncatch-Apé, by M. Quatrefages. This American Indian undertook a journey to the north-western coasts of America at the beginning of last century, in search of the origin of his race; whilst on this coast he learned and witnessed that it was visited every year by white men with long black beards, and M. Quatrefages proves that these men were originally from the Loo-Choo islands.—On the first meteorological, topographical, and hydrographical observations at the future Panama canal, by M. de Lesseps. Several maps of the coast are prepared, and a meteorological station is opened at Colon.—On the application of electromotive power and of M. Planté's secondary piles to the direction of aërostats, by M. Tissandier. In an aërostat which has a volume of 2200 litres, 3·50m. long, with a diameter of 1·30m., and can raise a weight of 2 kilogrammes, having a Siemens machine which weighs 220 grammes, and a secondary couple of 1300 grammes, the propulsory helix makes six and a half revolutions per second, and the balloon acquires a speed of 1 metre per second for forty minutes. The small Siemens machine, with three elements, produces the work of 1 kilogrammetre.—The elements of comet *c* of 1881 (Schäberle), by M. Bigourdan, as deduced from observations at Vienna on July 18, and at Paris on July 23 and 28. Its brightness, which is still increasing, will be on August 23 seventeen times as much as it was on July 18.—Spectroscopical observations on the comets *b* and *c*, 1881, by MM. Thollon and Tacchini.—On the lengths of spectral bands given by compounds of carbon, by M. Thollon.—On the constitution of comets, by M. Prazmowski.—On the theory of trilinear forms, by M. Le Paige.—On the influence of pressure on dissociation, by M. Lemoine.—On the heat of formation of explosives, by MM. Sarrau and Vieille.—On oxycyanides of lead, cadmium, and mercury, by M. Joannis.—On the heat of combustion of heptane and of hexahydrotoluene, by M. Louguinine.—Third note on the magnesia industry, by M. Schlösing.—A contribution to the study of the transmission of tuberculosis, by M. Toussaint. The juices of animals which have had tuberculosis transmit the disease with very great ease, even when submitted to a high temperature, but especially when employed uncooked.—On the injection of the virus of rabies into the circulation, by M. Galtier. It seems to prevent infection.—On hemeralopia and on the functions of the visual purple, by M. Parinaud.—On the applications of electromotors, by M. Trouvé.

VIENNA

Imperial Academy of Sciences, July 21.—L. T. Fitzinger in the chair.—A. Rollett, on the derived albumins noted as acid-albumins and alkaline albuminates.—Dr. Stur, on the Silurian flora of the H-h_1 stratum in Bohemia.—S. Lustgarten, on an ethyl nitrate formed by the action of nitric acid on glycogen.—Ernst Lecher, on the spectral distribution of radiant heat.—Dr. T. Kessel, on the function of the external ear in relation to the space-perception.—On the difference of intensity of a linear-produced sound in different directions, by the same.—F. Fossek, on the products of condensation of isobutyl aldehyde.—Zd. H. Skraup, on quinine and quinidine.—Note on some quinine compounds, by the same.—Prof. Freund, on the formation and preparation of trimethene alcohol from glycerine.—Preliminary note on trimethene, by the same.—H. Weidel, on a compound isomeric to α-sulphocinchoninic acid.—G. Goldschmidt, on mono- and dinitropyrene and amidopyrene.—E. Weis, a communication on the third comet of the year 1881 (1881 *c*), discovered by Schäberle at Ann Arbor (Michigan).—T. Woehner, report on his observations of the earthquake phenomena in Croatia in the year 1880.

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