in addition to those mentioned in my paper read before the Royal Society, will, I hope, justify me in having advanced a theory of magnetism which I believe in every portion allows at least experimental evidences of its probable truth.

THE REDE LECTURE

THE following abstract report of Prof. Huxley's Rede Lecture given on Tuesday week in the Cambridge Senate House, to a crowded audience, has been revised, to the extent of removing any errors of importance, by the author. We understand that a full report of the lecture will shortly be published in a separate form.

Professor Huxley said he had undertaken to treat in the course of such time as custom and the patience of his audience might permit, on a very great subject, no less a subject than the origin of all those forms of animal life which at present existed. It had behoved him to restrict what he might lay before them to those considerations which were absolutely essential for his purpose, and he should endeavour to lay before them facts of such an order as appeared to him to be of most importance in reference to his argument. Although he might fail to put those facts before them as clearly as they presented themselves to his own mind, the reasonings which might be based upon them were of so simple an order that he should consider his task performed if he gave them a tolerably clear conception of what those facts were, for he did not think it was the business of a man of science to use the arts of rhetoric or endeavour to procure persuasion. His sole business was to place the facts before those whom he wished to teach, and to leave it to their reason to form such judgment upon those facts as they might think fit. In the present case he should point out to them what judgments such facts had forced upon his mind, but he must leave it entirely to their responsibility to say what judgment they might constrain them to give in their case. They might assume this position at starting, that, whatever in such a matter was true for one animal, was true for the infinite series of the whole animal world; and as he was extremely anxious to avoid everything speculative, everything that could not be directly led back to the matters of fact upon which it was based, he proposed to select one animal particularly, and to put before them facts and arguments by the help of which they might form some probable conclusion as to the origin of that object. He took it for granted that, if the evidence inclined towards a particular conclusion in the case of that animal, they might assume that it would incline in the same direction with regard to all. He had no doubt that a great many of his audience were familiar at any rate with the shell of the animal about which he was going to speak, namely, that of the pearly nautilus, from which, or parts of which, very beautiful ornaments were fabricated. At the present time the nautilus inhabited the warmer parts of the Indian and Pacific Oceans, living at considerable depths and preying upon the hard shelled crustaceans and mollusks that crept along the bottom, and which it found in its way. For that end it was provided with a very curious beak, shaped like that of a parrot, but with each portion covered with a hard calcareous deposit, and which enabled it to be an efficient instrument for crushing its prey. If he were to touch upon the morphological problem which here presented itself, he could occupy far more time than they had at their disposal with the consideration of a multitude of interesting peculiarities which the nautilus presented, for it was one of those forms which at present stood almost isolated and alone in the animal world, separated by a wide gulf from its nearest allies, those animals which they knew as squids and cuttle-fishes. It held the middle place between sea-snails and the group of the cuttle-fishes. It would be, however, entirely out of place at present, and a purposeless waste of time if he were to touch upon any peculiarities except those which would be needed during his further argument. The only points to which he would direct their attention for that purpose were the facts which related to the structure of the shell. There was a diagram beside him showing a part of the nautilus shell in section, but he thought it possible that he could make the matter clearer by roughly sketching on the board the main points as he went on.—Prof. Huxley here described, with the aid of diagrams, preserved specimens, and models, the complicated structure of the shells of the pearly nautilus, or *Nautilus pompilius*. The animal itself was contained in the spacious chamber in the outer part of the shell, which was divided from the rest of the shell by a partition. The rest of the shell resembled a long cone closely coiled up, and divided by partitions at regular intervals into other chambers, which succeeded one another, and in the full-grown animal were full of air. From the hinder part of the animal's body a long tube, the siphuncle, was carried backwards through the whole of the shell, and as it completely filled up the openings in the partitions through which it passed there was no communication between one chamber and another. The first point to be considered was as to what was the origin of the particular nautilus in the bottle before him. Happily there was no dispute upon that point. The female nautilus contained eggs exactly as the hen did. These eggs were small masses of protoplasmic matter, each containing a nucleus in its centre, which was all that was essential. They knew that that pearly nautilus with all its complicated organism, and fitted with the complicated shell he had described, did, in some way or other, proceed from that relatively structureless body which they called the egg or the ovum. As fate would have it, up to the present they had known nothing from direct observation of the process by which that particular animal was produced from this microscopic particle. But they had so large a knowledge of the process in other animals of every description that there was no doubt whatever as to the nature of the process, which he would try to describe to them as briefly as possible, by reference to the process which took place in the case of the domestic hen. Neither by the highest powers of the microscope, nor by other means of investigation which they had at present, could they trace anything in the slightest degree resembling either the chick, which under certain circumstances proceeded from that egg, or the tissues of the chick. There was, however, one spot on the yolk of the egg, a little careful observation of which would show a clear space, which might be a fifth of an inch in diameter. It was very well known by the name of the cicatricula, or little scar. He would suppose that twenty-one eggs were placed together under the hen. If they took one egg day by day and examined it they would know what took place as if they had watched continuously, for what happened in any one egg happened also in the others. That was a process—the wonder of which he must confess never staled in his mind—by which the chick was gradually fashioned out of that transparent rudiment. They saw it make its appearance in the first place on the surface of the yolk, and to the naked eye it looked like a white streak. That white streak gradually assumed the appearance of a sort of elongated body, and that body shaped itself so that it could be seen that it was going to be an animal of some kind, it having a large head, and the rudiments of eyes and vertebræ. On the fifth day they could clearly see what they were going to have. Gradually, step by step, and moment by moment, new differences made their appearance from the original foundation, and until many days before hatching there was an unmistakable bird, and at the twenty-first day there emerged from the shell an animal endowed with all a bird's capacities and structures. That process was the process of development. If they inquired into the nature of the cicatricula, they would find that that was merely a double layer of minute nucleated cells. They would find that that resulted from the splitting up of a protoplasmic mass that had been there before. They could trace the process back into the body of the hen until they came down to a simple nucleated cell, so that it was a matter capable of demonstration that in that nucleated cell which formed a part of the egg organ of the hen—in that particle of, for morphological purposes, structureless jelly, were the same characteristics which were possessed by the very lowest forms of animal life which were known. They knew that in that particle resided a potentiality, capable of developing itself through the stages he had roughly indicated, until it became not only a machine of the highest order from a physiological point of view, but a very remarkable work of art. That particle of protoplasmic matter did that in virtue of the powers inherent in its material nature. That was the point he wished to put before them as clearly and definitely as he could, because it would be fundamental in all further discussion. For it was to the process he had briefly described that the great discoverers of the last two centuries applied the name of "evolution." Singularly enough the persons who first used that name did not use it in that sense in which it was universally used now, because they were under a mistake as to the exact nature of the process. But the whole conception of evolution was now based upon ascertained facts, showing the process of development of the most complicated animal out of a relatively structureless particle, which had no higher organisation than that of the

lowest animal they knew, a process which progressed step by step by means of the gradual addition of small differences, until the animal attained its perfect form. That was what was meant by the process of evolution. At this point he thought it might be desirable that he should deal with what he might speak of as the *a priori* objections to the doctrines of evolution. He had had opportunities of making extensive acquaintance with those objections during the past twenty years or so. He divided them into three categories: (1) That evolution was impossible; (2) that it was immoral; and (3) that it was opposed to the argument of design. Now that was a very heavy indictment, but he thought they must plead "not guilty" upon all three counts. It required no great amount of reasoning to convince one that that which happened could not be impossible; that that which happened thousands and millions of times every hour and every minute in this world as it now was, under certain conditions, could not be held without further evidence to be impossible under somewhat different conditions. Secondly, with regard to the question of morality. He had never understood that argument, and had always been disposed to reply that the morality which opposed itself to truth committed suicide. With regard to the argument of design he would not discuss that point himself, but would beg them to listen for a moment to words that would carry far more weight than any of his own could carry on that topic:—"The philosopher beholds with astonishment the production of things around him. Unconscious particles of matter take their stations and severally range themselves in an order so as to become collectively plants or animals, *i.e.* organised bodies with parts bearing strict and evident relation to one another and to the utility of the whole; and it should seem that these particles could not move in any other way than they do, for they testify not the smallest sign of choice, or liberty, or discretion. There may be particular intelligent beings guiding their motions in each case, or they may be the results of trains of mechanical dispositions fixed beforehand by intelligence or appointment and kept in action by a power at the centre." They might imagine, and not unreasonably, that those were the words of some ultra-evolutionist of the present day who desired to set himself right with the argument from design; but they were not so. They were more than eighty years old, and they were contained in the 23rd chapter of a book which was very much talked about, but, he was afraid, very little read, namely, the "Natural Theology" of Archdeacon Paley. When he was a boy that book was a very great favourite of his, partly for its own merits, and partly because it was one of the few books he was allowed to read on Sundays. He found it much more entertaining than most of the books included in that category. But from what had been since said of the Atheistic tendencies of the doctrine of evolution he began to think that he stood before them a miserable example of the manner in which a man's mind might be poisoned by early instruction, and that his incapacity to understand the force of the arguments against evolution arose from the circumstance that in his early childhood he was indoctrinated with the reasonings of a great divine of the Church.—Professor Huxley now proceeded to consider the next point, the coming into existence of the nautilus species in contradistinction from the origin of a particular nautilus as an individual. He showed that, according to all the evidence that could be gathered, there was every reason to believe the forms of animal life five thousand years ago were practically the same as they were now. If there were no other means of knowing anything about the history of animal life, undoubtedly this experience, resting upon a duration of five thousand years, would have furnished an apparently sufficient basis for a generalisation, tending to the conclusion that the forms of animal life had not changed during that period. Not only had that generalisation been made, but it had been concluded that the forms of animal life were unchangeable, a totally different proposition, the validity of which rested, among other things, on the proportion between our actual experience, supposing it to extend over that time, and our possible experience of the duration of life on the globe. It would, he thought, be absolutely impossible for any of them, however good their vision, to say from actual observation of the hour hand of a watch for four seconds that it had moved during that interval, and in point of fact the space over which it would move was so minute as to be indiscernible, even through a magnifying glass. Yet they knew very well that it had moved, and if they watched it for four or five minutes, the evidence of its movement would be perfectly obvious, even to the naked eye. They would observe, therefore, that a period of observation which extended over the nine-hundredth part of an hour, would give them no conception from which it would be possible to draw a conclusion as to what had happened during the total period. Now geologists told them that the whole depth and extent of the fossiliferous rocks, which composed a considerable portion of the earth's crust, represented a period of time at least one thousand times as great as the historical period. That was a point upon which there could be no room for hesitation. Hence it followed that when they acquainted themselves with the succession of animal forms which were embedded at different depths in the earth's crust, they did exactly what the observer of a watch did when he kept his eyes fixed on it, not for four seconds but for an hour, in which latter case the movement was not only conspicuous, but such as commonly served to indicate the lapse of time. If that analogy held good, the slow procession of events which might be absolutely indiscernible in the course of 5,000 years, would become obvious and plain when the period of observation was extended to a thousand times that period. And that was exactly what happened, for if they went back in the series of stratified rocks they found the genus nautilus, which in the present day was represented by one or two species, represented in the long period of its history by many other species. As far back as the Upper Silurian formation the genus nautilus was represented by an abundant number of shells fabricated by animals having all the essential peculiarities which he had described. In the geological specimens before him, and which were taken from the rich collection in the Woodwardian Museum, there were forms of nautili which no one doubted were to all intents and purposes the same in their general structure as the pearly nautilus of the present day, although they were at least 5,000,000 years old. Now came the main question: were those nautili whose history extended back through such a prodigious range of time identical in character with the modern species? So far as he knew there was nothing in the nature of things to show why a succession of generations which remained unchanged through 5,000 years should not remain so for 50,000 or 50,000,000 years. The facts, however, showed that there had been rather more than 100 distinct species of nautilus, each having as good a title to be called a species as *Nautilus pompilius* itself. No one of these species had endured for more than a portion of the duration of the whole genus, and many species had existed contemporaneously, those species, however, except perhaps two, were now extinct, so that now they were brought face to face with the heart of the question: by what hypothesis could they account for those phenomena? They were driven into hypothesis of some kind or other, because it was impossible to have any evidence of contemporary witnesses of facts which went so far back into the past. So far as he knew there were only two possible alternative hypotheses by which they could pretend to account for those facts. One of these hypotheses was what he ventured to call the hypothesis of construction. That hypothesis was that every one of those species was put together. It was making a needless difficulty to suppose that each species came out of nothing, because they knew that the body of the nautilus was made up of materials which were familiar to them in an inorganic state on the earth's surface; so that by the hypothesis of construction some agency had put together those materials a hundred times or so during the period that had elapsed from the formation of the Silurian rocks to the present day, as an artist constructed his work, or as a mechanician put together the parts of his machine. That was one hypothesis. For his part, he had not a word to say *a priori* against the possibility of that hypothesis. It was certainly conceivable and therefore, according to Hume's maxim, it was possible. But they must bring it, like all other hypotheses, to the test of facts and inquire how far it stood that test. He thought the hypothesis of construction presented two large and almost insuperable difficulties. The one was that it was absolutely opposed to everything that they had received traditionally concerning the origin of animal forms, and the second was that it was no less opposed to every doctrine which might reasonably be held upon grounds of sane science. It stood to reason and common sense that they could have recourse only to those causes for the assumption of which there was some ground of analogy. The business of science would be extremely easy if for every event one were permitted to invent special causes having no analogy in nature. The difficulty of science was in tracing every event to those causes which were in present operation. That difficulty was being so constantly overcome that it had become a canon of

physical science no less than it was a canon of historical science that speculation should confine itself to construing past events by the analogy of those of the present time. The hypothesis of construction seemed to him unacceptable, because it led them into contravention of tradition on the one side and into contravention of scientific logic on the other. The only other alternative hypothesis was that of evolution, which meant that the different forms of animal life had not arisen independently of each other in the great sweep of past time, but that the one had proceeded from the other; and that that which had happened in the course of past ages had been analogous to that which took place daily and hourly in the case of the individual. That was to say that just as at the present day in the course of individual development the lower and simple forms, in virtue of the properties which were inherent in them, passed step by step by the establishment of small successive differences into the higher and more complicated forms, so, in the case of past ages, that which constituted the stock of the whole ancestry had advanced grade by grade and step by step until it had attained the degree of complexity which was seen at the present day. No objection could be brought against this hypothesis on the ground of analogy, because in putting it forward they were not bringing in any kind of causation which was not abundantly operative at the present time. The question was whether the history of the globe in past time coincided with this hypothesis, and to that point he would next address himself. What did they find if they considered the whole series of these forms? Unquestionably, as he had said, nautili were found as far back as the Upper Silurian age. Before that time there were no nautili, but there were shells of the *Orthoceratidæ*—of which there were magnificent examples before him—which resembled those of the nautili in that they were chambered, siphoned, &c., with the last chamber of such a size that it obviously sheltered the body of the animal. He thought no one could doubt that the creatures which fabricated these still earlier shells were substantially similar to the nautili, although their shells were straight, just as a nautilus shell would be if it were pulled out from a helix into a cone. Then came the forms known as the *cyrtoceras*, which were slightly curved. Along with these they had the other forms which were on the table, and in which the shell began to grow spiral. The next that came were forms of nautilus, which differed from the nautilus of to-day in that the *septa* were like watch-glasses, and that the whorls did not overlap one another. In the next series, belonging to the later palæozoic strata, the shell was closely coiled and the *septa* began to be a little wavy, and the whorls began to overlap one another. And this process was continued in later forms, down to that of the present day. Looking broadly at the main changes which the nautilus stock underwent, changes parallel with those which were followed by the individual nautilus in the course of its development, he considered that there could be no doubt that they were justified in the hypothesis that the causes at work were the same in both cases, and that the inherent faculty, or power, or whatever else it might be called, which determined the successive changes of the nautilus after it had been hatched, had been operative throughout the whole continuous series of existence of the genus from its earliest appearances in the later Silurian rocks up to the present day. What the whole question, in whatever way it might be put, came to, was this: Successive generations of animals were so many cycles of evolution that succeeded one another. Within the historical period, there was no doubt that, speaking roughly, those succeeding cycles had been identical, that was to say, without discernible difference. But when the period of observation became proportional to the slow rate of change they found, so to speak, that the hour hand had moved; for, in the successive cycles of evolution which had occupied the whole period, successive cycles had differed from one another to a slight extent. If they might assume that, then the whole of the phenomena of palæontology would fall into order and intelligibility. If not, they had to adopt an hypothesis which, as he had pointed out, had no support in tradition, and which was absolutely contradicted by every sound canon of scientific research. This was his case for evolution, which he rested wholly upon arguments of the kind he had adduced. From the time when he first read Charles Darwin's "Origin of Species," now some twenty-four years ago, his mind had fixed itself upon the tenth chapter of that book, which treated of the succession of forms in geological times, for it appeared to him that that was the key of the position; that if the doctrine of evolution was correct, the facts of palæontology, as soon as they became sufficiently known, must bear it out and verify it in every particular. On the other hand, he believed that, if the facts of palæontology or the historical facts of life on the globe were against evolution, then all the rest of the argumentation in its favour would be vain and empty, because the difficulty of adopting it would be in that case absolutely insuperable. He would venture to repeat that the occurrence of evolution was a question of history. He did not know whether Sir Henry Maine was not more competent to speak on that point than he was. It was a question as to whether they would interpret the facts of animated nature scientifically, or whether they would open the door to every description of hypothetical vagary. He came to the conclusion that that was a point worth testing in every possible way, and for some twenty years he had given what leisure he had been able to beg, borrow, or sometimes steal, to the investigation of these questions. He had endeavoured to ascertain for himself how the doctrine of evolution fitted with the facts of palæontology with regard to the higher vertebrated animals, and with regard to the chief varieties of invertebrate animals, and all he could tell them was that the farther his own investigations had gone, the more complete had appeared to be the coincidence between the facts of palæontology and the requirements of the doctrine of evolution. The conclusion he had come to was that at which every competent person who had undertaken a similar inquiry had arrived, and if they would pay attention to the writings of such men as Gaudry, Rütimeyer, Marsh, Cope, and others, who had added materials upon which to form a judgment such as were not dreamt of when Darwin first wrote, they would find that they all without hesitation attached themselves to the doctrine of evolution as the only key to the enigma. In deciding the issue between the two hypotheses, serious inquirers would not trouble themselves about any collateral points as to the how and the why, or as to any of the subordinate points at issue. He thought he was entitled to entreat those who by their calling or by their position in society, or by the fact that they possessed any influence, might be led to express an opinion upon this matter, to look into the arguments which formed the foundation of the case for evolution. Happily, he might address that recommendation to members of the University of Cambridge with a perfectly good conscience, for at this present time he knew not where in the world any one could find better means of passing through all those preliminary studies which were essential to a comprehension of this great question, or where any one could find more amply displayed the means of testing the arguments which he had laid before them. He ventured to say that the members of this University were without excuse if they gave opinions on this question of evolution without having prepared themselves, by as diligent study as they would for the purpose of approaching questions of literary or theological criticism, to express an opinion upon it. These were the considerations which he had wished to set before them that day. It would be understood that they would not suffice to enable any one to form a judgment upon the doctrine of evolution, but he hoped that they had sufficed, brief and insufficient as they were, to show that if judgment on this question was to be worth anything intellectually, if it was to be creditable to the moral sense of those who formed it, it would first be necessary that the facts should be clearly comprehended, and that the conclusion—whatever it might be—should be one which right reason would admit might be justly and perfectly connected with the facts.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

OXFORD.—The term that has just concluded has been chiefly noticeable for the interest drawn towards Oriental studies in the University by the building of the new Indian Institute. The visit of the Prince of Wales to the Chancellor of the University served to draw national attention to the work which Oxford, and especially Balliol College, has undertaken in respect to the training of the selected candidates for the Indian Civil Service. In spite of the failure of the late attempt to induce the University to relax its rule requiring three years' residence as a qualification for a B.A. degree in the case of the Indian Civil Servants, a considerable proportion of the selected candidates come into residence at the University; Balliol, by providing teachers and tutors in Oriental subjects, attracts by far the greatest number.

With the exception of two debates there has been little excitement during the term in the Convocation House. The two questions that roused general interest were, first, the proposal that