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WHAT AMERICAN ZOÖLOGISTS HAVE DONE FOR EVOLUTION.[1]

By Professor EDWARD S. MORSE.

I.

IT would be pleasant indeed if only a lecture or an essay were expected from the presiding officer of the Section; but an address implies a great deal more, and the giver of it is not only expected to be entertaining, where perhaps he never entertained before, but instructive upon grounds upon which, perchance, he has made but partial survey. Among the many questions of sustaining interest, a number of subjects intrude themselves. A general review of the work accomplished since the last meeting of the Association would seem an appropriate subject for discourse. Yet beyond my special studies I feel quite incompetent to scan so broad a field. In this year of Centennial reviews, one might naturally fall into an attempt to sketch the growth of science and the work accomplished within the last hundred years, but that would not only be too vast a field, but would on the whole be unprofitable, since time-boundaries, like the surveyor's lines bordering a State, have no definite existence in Nature. The natural boundaries of oceans and sierras do indeed isolate and impress peculiarities of thought and action upon man, as upon the creatures below him, and for this reason we may with propriety examine the work of our nation in any line of investigation. Never before has the study of animals been raised to so high a dignity as at present. While chemistry could point to its triumphs in the arts, and geology to the revelations of hidden wealth in the rocks, zoölogy was for the most part a mere adjunct to geology, or a means to thwart the

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in America than in England, and quite as safely. In fact, I had reason to believe that the warmth of my own welcome in America was in no small degree due to the fact that, having first proved the justice of my views, I had not been afraid to maintain them publicly against the powers that were until the proper course was adopted.

One other point remains to be noticed, the influence, namely, of religious scruples upon scientific progress and research in America. Here I must admit that I was somewhat disappointed. I expected to find America a long way in advance of England. But with some noteworthy exceptions, especially in the West, America seems to me to be behind England in this respect. It is only here and there, in England—in the Bœotian corners, so to speak, of this country—that the community opposes itself to advanced scientific ideas to the same extent as in some of the leading cities of the United States. This is partly due to two opposite influences: the Puritan element of the American population on the one hand, and the Roman Catholic element on the other. Progress, however, is being steadily made in this as in other matters. Indeed, it has been rather because America began later to bestir itself in the encouragement of free search after truth that she is at present behind England in this respect. Judging from experience in other matters, she will move rapidly now her progress has begun, and will soon occupy the position to be expected from the natural freedom and independence of the American mind. It need hardly be said that in America, as in Europe, such contest as arises from time to time between religion and science has its origin entirely from the side of religion. There as here religion (so called) attacks and denounces discoveries inconsistent with the views which the orthodox had been accustomed to advocate; and there as here, when there as no longer any choice, the orthodox quietly accept these discoveries as established facts, expressing a *naïve* astonishment that they should ever have been thought in the least degree inconsistent with received opinions.—*Advance-sheets of Popular Science Review.*

IS THE DEVELOPMENT HYPOTHESIS SUFFICIENT?

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THIS paper has been occasioned by the lectures of a distinguished Englishman who has visited this country; but I am to keep very much to my general subject, and not enter upon a minute criticism of Prof. Huxley. In these lectures he has abstained from entering on those exciting topics bearing on materialism and religion, which he has discussed so freely in Edinburgh and in Belfast, and in his published writings. So far the hopes of unbelievers in Scripture, and the fears

of timid Christians, and the rising rage of polemic theologians, have been disappointed. But an interest has been excited in the subject of development. In the present state of the public mind, good may arise from showing that when the doctrine of development is properly explained and understood, and kept within its legitimate sphere, there is nothing in it inconsistent with natural or revealed religion; and that the scientific truths which Prof. Huxley has expounded in these lectures do not entitle him to draw the consequences which he has done in his "Lay Sermons" and other writings.

In his first lecture the professor had light work and an easy victory. He set up two targets and shot them down. He stated and overwhelmed two hypotheses: the first, that Nature has been all along very much in the same state as it now is; and the second, the poetical account given by Milton in "Paradise Lost." It did not need an Englishman to come 3,000 miles, it did not require a man of Prof. Huxley's knowledge and dialectic skill, to demolish these fancies. I cannot remember a single man eminent in science, philosophy, or theology, defending either of these views during the last half-century. The first hypothesis was never held by religious men, though it has been defended by a few scientific men—who might have been kept from error by looking to Scripture—such as Hutton, Playfair, and Lyell in his earlier writings. The book of Genesis speaks of an order and a progression in the origination of things and of a flood covering the then peopled earth. I should not expect any one but a Don Quixote to attack Milton's exposition of a popular belief. The view given in "Paradise Lost" was not the one entertained by several of the most eminent of the Christian fathers, such as Origen, and has not been entertained by any theologian of ability and scholarship for the last age or two. It must now be forty or fifty years since Chalmers and Pye Smith and certain well-known divines of the Church of England, and President Hitchcock of Amherst, adopted the discoveries of geology and sought to reconcile them with Scripture. It is an instructive circumstance that, while Milton's account cannot stand a moment's investigation, the record in Genesis is believed by many of our highest men of science to be perfectly consistent with the latest science. I name only Prof. Dana, Prof. Guyot, and Principal Dawson, the highest authorities on this continent, and superior to Prof. Huxley, not certainly in zoölogy, but in geology. I am quite ready to give up these two hypotheses to Prof. Huxley, to hew and hack them (to use one of his own phrases) like Agag.

The second lecture is written in his best manner. There is scarcely anything in it that I am inclined to object to. He is no longer killing hypotheses which died a natural death long ago. He is arranging his materials for the defense of the theory of Evolution. He has as yet only brought forward the cases which he acknowledges are not demonstrative of the truth of evolution, but are such as must exist if

evolution be true, and which, therefore, are upon the whole strongly in favor of the doctrine of development. He makes a number of admissions. He allows that there are species which have continued unchanged, not only throughout all historical years, but all geological ages. Cuvier has shown that the ibises, dogs, and cats depicted 3,000 years ago or more on the monuments of Egypt are the same as those found in that country in the present day. The professor mentions a fish of the chalk formation named cericus, which is represented at the present day by a very closely-allied species living in the Atlantic and Pacific Oceans. He thence argues that there is no intrinsic necessity in animal forms to change and to advance, as some sciolists assume. But he labors to prove that there are cases in which varieties have become species by reason of being suited to their surroundings. He gives credit to Mr. Darwin for bringing in two great factors in the process of evolution: "One of them is a tendency to vary, the existence of which may be proved by observation in all living forms; and the other is the influence of surrounding conditions upon what I may call the parent form, and the variations which are thus evolved." He adds: "The production of variations is a matter *not at all properly understood at present.* Whether it depends on some secret machinery —if I may use the phrase—of the animal form itself, or whether it arose from the influence of conditions upon that form, is not certainly a matter for our present purpose." True, this may not be for the purpose of his lecture, but it must be cleared up before we can clear up the subject of development. The nature and laws of variations and the peculiar laws of heredity are at present shrouded in mystery. When we know more of them and of the forces at work, we shall be in a better position to determine whether varieties ever do become distinct species.

The professor acknowledges that geology does not furnish decisive evidence of one form of life passing into another. But then he claims that the geological record is not complete; that much of what is written in stone has been effaced, and that if it were complete it would show us the missing links. To equal him in candor I admit that transitional forms are ever casting up. He shows that in certain fields we have those transitions already disclosed. He dwells on the resemblances and the affinities between reptiles and birds, and refers to animals which have some of the properties of both. Thus there are birds that have teeth, and reptiles that have wings and can stand on their two hind-legs, such as the *hadrosaurus* found in New Jersey. His demonstration, as against Owen, seems to me complete here. True, there are naturalists who maintain that the teethed bird is still a bird, and the archeoptrix a reptile, a variety and not a transitional form. Still, such cases indicate a tendency on the part of the reptile to rise to the bird, and of the bird to retain properties of the reptile; and natural selection and development alone can explain this.

In his third lecture he brings forward what he regards as a demonstration. In the case of *Equus*, embracing our horse, ass, and zebra, he is able, by means of the specimens gathered in the West by Prof. Marsh, to discover the succession of horse-like forms which the hypothesis of evolution supplies. He goes back from the living horse through the like animals of the post-Tertiary in the Pliocene, middle, and earlier on to the older Eocene formation, where he finds the orohippus. "There you have four toes on the front-limb complete, three toes on the hind-limb, a complete and well-developed ulna getting forward an equality of size with the radius, a complete and well-developed fibula apparently, though it is not quite certain, and then teeth with their simple fangs. So that you are now able, thanks to these researches, to show that, so far as our present knowledge extends, the history of the horse-type is exactly and precisely that which could have been predicted from a knowledge of the principles of evolution, and the knowledge we now possess justifies us completely in the anticipation that, when the still older Eocene deposits and those which belong to the Cretaceous epoch have yielded up their remains of equine animals, we shall find first an equine creature with four toes in front and a rudiment of the thumb, then probably a rudiment of the fifth behind, and so, by gradual steps, until we come to that five-toed animal in which most assuredly the whole series took its origin. That is what I mean, ladies and gentlemen, by demonstrative evidence of evolution."

Suppose that we admit all that the lecturer claims on this subject: what then? Have we thereby set aside any doctrine of philosophy or religion? The Christian, even the Christian theologian, may say wisely: "Let naturalists dispute as they may about the derivation of plants and of the lower animals; their hypotheses, arguments, and conclusions, do not interfere with our belief that God is to be seen everywhere in his works and rules over all." It appears to me that the whole doctrine of vegetable and animal species needs to be reviewed and readjusted—and religion need not fear the result. I have been convinced of this ever since I learned, when I was ardently studying botany, that the number of species of plants had risen to two millions! I was sure that all these are works of God; but I was not sure that each was a special creation.

When a new truth is discovered, especially when it is a reaction against an old theory, it is apt to bulk so largely in the view of those who hold it that they carry it to extreme lengths, and it requires time and discussion to confine it to its own place. Thus, in old time, Thales perceiving how much water could do, and Anaximenes how much air could accomplish, and Pythagoras how much numbers and forms could account for, hastened to the conclusion that the whole operations of Nature could be derived from them and explained by them. I am old enough to remember that the brilliant discoveries of

Sir Humphry Davy led wandering lecturers and all sorts of sciolists to affirm that they could explain all things, matter and mind itself, by electricity. So, in these days, development, having furnished a key to open so many of the secrets of Nature, has led some to imagine that it can solve all the mysteries of the universe. Some of us may be inclined to admit, and to use for scientific purposes, the doctrine of development, and yet be prepared to deny that it can explain everything. The fact is, it overlooks a great many more things than it notices. There are signs of a reaction among scientific men against its extreme positions; and it is the work of the age now present to show how much development can do, and how much it cannot do. Even Darwin is obliged to call in a few germs created by God, and a pangenesis in order to account for development. Herbert Spencer acknowledges a great Unknown behind visible phenomena. Huxley recommends a worship chiefly "of the silent sort." Religion comes to them and says, "Whom, therefore, ye ignorantly worship him declare I unto you."

In the common apprehension of those who hold the development hypothesis, all that is necessary to account for the world in its present state is to suppose that millions of years ago there appeared—no one can tell how—a nebulous mass with an inconceivably high temperature, but losing its heat and ready to condense; that in the long lapse of time it took the shape of planets, satellites, and sun; and that on one of these planets—that on which we dwell—it formed into plants, animals, and finally man, all by its own power, according to natural law, or, rather, the necessity of things, without it being necessary to call in a God or a guiding providence, or to suppose that there has been a plan in a designing mind. All the defenders of the theory do not state this in express words, but it is the impression left by their expositions, though some of them, such as Herbert Spencer and Tyndall, would save themselves from the blank consequences by calling in an unknown and unknowable power beyond the visible phenomena, or by appealing to some religious feelings supposed to be deep in our nature, but which the theory would soon undermine, as being, in fact, unjustifiable and unreasonable. This is the view that I mean to meet. In examining this hypothesis there are some things which I am willing to admit as being established truths:

1. I hold the doctrine of the Conservation of Force—that is, that the sum of energy, real and potential, in the universe is always one and the same, and cannot be increased or diminished by human or mundane action. I was prepared for this doctrine when it was announced by Mayer, of Heilbronn, and by Joule, of Manchester, and expounded by Grove, of London. It seemed to me to follow from the doctrine which I had laid down in my first work—"The Method of Divine Government"—published twenty-six years ago: as to the material universe being composed of substances with properties or pow-

ers of which it cannot be deprived, and which cannot be added to nor lessened. It is this that secures the permanence of Nature, keeping it unchanged in its power or powers amid all changes of action. This energy, disappearing in one form, appears necessarily in another, and gives us what Spencer calls the "persistence of force." This ever-enduring force gives rise to development. Going out from one body, it is manifested in another. The fact is, all causation, all physical action, is evolution. The substances and powers in the agents acting as the cause are found, though in a modified form, in the effects. Proceeding on this very principle, Mayer says: "Forces are causes; accordingly, we may in relation to them make full application of the principle *causa equat effectum*," and he thus elaborated the grand scientific truth, the most important discovered in our day, that the sum of energy in the universe is always the same.

2. I admit that this power becomes more and more differentiated, that is, takes more and more diverse forms, and thus imparts an ever-increasing multiplicity and variety to the universe, and will continue to do so till the diversity breaks it up, and "the heavens shall pass away with a great noise, and the elements shall melt with fervent heat, the earth also, and the works that are therein shall be burned up." Mr. John S. Mill has been successful in showing that there is usually more than one antecedent or agent in a cause. "A man takes mercury, goes out-of-doors, and catches cold. We say, perhaps, that the cause of his taking cold was exposure to the air. It is clear, however, that his having taken mercury may have been a necessary condition of his catching cold; and though it might consist with usage to say that the cause of his attack was exposure to the air, to be accurate we ought to say that the cause was exposure to the air while under the effect of mercury." He concludes, "The real cause is the whole of these antecedents." Now, I hold that in physical Nature causes are not only usually, but invariably, of this dual or plural nature. I go a step farther, and have shown, I think, that the effects are also of the same dual or plural character. The effect, in fact, consists of the same agents or substances as the cause, but now in a new state. A picture falls from a wall and breaks a table; we say that the breaking of the table was the effect of the fall of the picture. But the true effect embraces both the picture and the table, the picture having lost its momentum, and the table being broken. It follows from all this that the new combination of agents, acting as the causes, must produce more and more varied effects, as the effects joining with other effects become causes, and ramify into branches and branchlets. The sum of the powers is one and the same, but they appear in an ever-increasing number and diversity of forms. The conservation of force thus gives a unity to Nature, while the mutual action and interaction give it its multiplicity. I remember how deeply I was interested in that paper (I read it when it appeared) of Von Baer, in which he shows

that in the germs of animals, as in the history of the production of animated Nature through long ages, there are first greater unity and simplicity, and then specific varieties more and more divergent.

3. I have never set myself, as too many religious men unwisely did, against the theory, first started, it would appear, by Kant, then elaborated by Sir William Herschel and Laplace, and perfected, I believe, by a professor in Princeton College, that the mundane system may have been formed out of original matter, evolved according to the mechanical laws with which it is endowed—first the outer planets, then the inner, and finally the sun condensed into the centre. This never appeared to me to be an irreligious doctrine, though Laplace was unhappily a man without religion.

4. Once more, I have ever stood up for a doctrine of Development. There is a development of one form of matter from another, of one force from another. There is, as every one allows, a development of the plant and animal from the parent. I see nothing irreligious in holding that the bird may have been evolved by numerous transitions from the reptile, and the living horse the old horse of the Eocene formation. An accumulation of powers, new conditions and surroundings may, it is acknowledged, produce a variety which may become hereditary. Let us suppose that they can also, in rare cases of combination, produce species: religion is not thereby undermined, either in its evidences or in its essential doctrines.

The question now arises and presses itself upon us: Can we by these acknowleged agencies explain the whole of the present state of the universe, with all its fitnesses, its harmonies, its beauty, its utility, its beneficence? The development theory, in the narrow and exclusive form which it commonly takes, overlooks vastly more than it notices. In particular, there are four grand truths kept out of sight. Without these, we cannot understand the Cosmos. When these are introduced, they bring God into his own universe, and fill it with life and love.

1. *God is present in all his Works, and acts in all their Actings.* —This is the religious doctrine. "By him all things consist." Paul, addressing the men of Athens, said: "For in him we live, and move, and have our being; as certain also of your own poets have said, For we are also his offspring." This doctrine may be so stated as to make it pantheistic. It is the one grand truth contained in pantheism, giving it all its plausibility, and making it superior to that bald theism which makes God create the world at first, and then stand by and see it go. The doctrine can be so stated as to free it from all such tendencies on the one side or the other, so as to make God distinct from all his works, and yet acting in them. This is, I believe, the philosophical doctrine. It has been held by the greatest thinkers which our world has produced, such as Descartes, Leibnitz, Berkeley,

Herschel, Faraday, and multitudes of others. It seems to be required by that deep law of causation which not only prompts us to seek for a cause for everything, but an adequate cause, to be found only in an intelligent mind. Our greatest American thinker, Jonathan Edwards (whom I can claim as my predecessor), maintains that, as an image in a mirror is kept up by a constant succession of rays of light, so Nature is sustained by a constant forth-putting of the divine power. In this view Nature is a perpetual creation. God is to be seen not only in creation at first, but in the continuance of all things. "They continue to this day according to thine ordinances." He is to be acknowledged not only in the origination of matter, but in its developments; not only in the reptile and the bird, but it may be in the steps by which the one has been derived from the other; not only in the orohippus, but in the stages by which that animal has risen into the horse so useful to man.

2. *New Powers appearing in Nature.*—Let us suppose that there was an original matter. I regard it as most in accordance with the principles of our reason to ascribe that matter to God. What properties had that matter at first? Every man of ordinary wisdom and modesty will be ready to answer, "I know not." If he does not know, he is not entitled to say that all things have proceeded from it. I suppose it will be allowed that it possessed gravitation. "This law of the inverse square," says a writer in the last number of the *Quarterly Review* (London), "is but the mathematical expression of a property which has been imposed on matter from the creation. It is no inherent quality, so far as we know. It is quite conceivable that the central law might have been different from what it is. There is no reason why the mathematical law should be what it is, except the will of the Being who imposed the law. Any other proportion would equally well be expressed mathematically and its results calculated. As an instance of what would occur if any other proportion than the inverse square were substituted as the attractive force of gravity, suppose, at distances 1, 2, 3, the attractive force had varied as 1, 2, 3, instead of the squares of those numbers. Under such a law any number of planets might revolve in the most regular and orderly manner. But under this law the weight of bodies at the earth's surface would cease to exist; nothing would fall or weigh downward. The greater action of the distant sun and planets would exactly neutralize the attractive force of the earth. A ball thrown from the hand, however gently, would immediately become a satellite of the earth, and would for the future accompany its course, revolving about it for the space of one year. All terrestrial things would float about with no principle of coherence or stability—they would obey the general law of the system, but would acknowledge no particular relation to the earth. It is obvious that such a change would be subversive of the entire structure and economy of the world."

Much the same might be said of the chemical, the electric, and magnetic properties of matter. If they were among the original powers, there is proof of design in their adaptation to one another and to the matter of the universe. If they were not, then we have traces of a new power being introduced, and for this we must look for a cause. We are not able to say how many the properties possessed by the original matter; whether they were few or many. But in either case there is evidence of contrivance in their harmonious action and results. We see that there is an end proposed in the music that comes from a violin, and this whether it is brought forth from one string, as was done by Paganini, or from four strings, as is done by the ordinary performer. So in the orderly and beneficent action of Nature there is proof of adaptation, whether we suppose the original properties to be few or to be numerous.

Though preservation is in a sense a continued creation, yet preservation differs from creation. In looking back on the history of the world, it is often difficult to tell as to a certain work to which of these two kinds of divine acts it belongs. We may not be sure, for example, as to a new form of plant or animal, whether it is a creation or simply a development according to law; and I am not sure that religion gains by our taking one side or another. We cannot, we have seen, determine for certain what were the powers of Nature that were working from the very beginning. But it is clear and sure that powers have appeared in Nature from time to time which did not operate at first nor for long ages; nay, if geology speaks truly, nor for millions of years. There may be two suppositions in regard to these powers. The one is, that they were all along in the original matter; that the star-dust had in it potentially not only gravitation and chemical affinity, but life, sensation, consciousness, intelligence, moral discernment, love. It is hard to believe that there was all this in that dull, heated, nebulous matter from which our world sprang. It is acknowledged that this mass must have existed for a long time —for hundreds of thousands, probably for millions of years—before life, and for a far longer time before intelligence, appeared. Whence did these new powers come? If they were in the original matter, how did it come that they were so long dormant, how that they at last appeared, it might be shown, at the appropriate time when surroundings were prepared for them? Science can say nothing on this subject, and may never be able to say anything. It is passing altogether beyond its province, passing from inductive proof into speculation, when it pretends to know anything one way or other. Philosophy feels itself staggered when it would solve the problem. It does say, indeed, that this new operation must have had a cause. It is one of the certain laws of intelligence, one of the universal laws of experience, that everything that begins to be must have a cause. This law of causation takes several forms; but every form will insist that these new

operations must have come from a causal power. "Ex nihilo nihil fit" is a maxim going back farther than I am able to tell. The form given it by the great atheistic poet Lucretius is:

". . . Nihil posse creari.
De nihilo, neque quod, genitu est ad nihil revocari."

Persius puts it:

". . . Gigni
De nihilo nihil, in nihilum nil posse reverti."

Take either of these forms, or any form, and it insists that we seek a cause of the new kind of operation. It cannot discover that there was anything in that heated, vaporous matter to produce life and sensation, when they appeared millions of years after the world had begun to be formed. I will not decide dogmatically whether the causal action was natural or supernatural. Perhaps we are here come to a place where the distinction between natural and supernatural is lost in the dim distance. The cause may have acted according to a law. But in that case I must hold it to be a divine law. Even in the supposition that it has been brought about by a conjuncture of circumstances, unknown for the indefinite period before, it must have been a providential juncture foreseen, nay, ordained by God.

Life appears ten thousand ages or more after the earth began to form. Whence this life? Prof. Huxley seems to find it in some protoplasm or gelatinous substance. Was this one of the original elements of the nebulous matter? If so, how did it come through that terribly heated temperature? If it did not exist till after the temperature had cooled, how did it come in? Prof. Huxley has been the most determined opponent in our day of the spontaneous generation of life, and is thereby left without a means of generating the life of plants and animals. Darwin feels himself obliged, in order to account for the phenomenon, to suppose that there were four or five germs created by God. Tyndall thinks that Darwin has at this point fallen into a weakness. But, meanwhile, Tyndall has no means whatever of accounting for the appearance of life. Mr. Darwin further calls in a *pangenesis*—which is just another name for the *vital force* of the older naturalists—in order to account for the generation of new animals. But he does not tell us, and evidently cannot tell us, whence this pangenesis, which cannot come from development, of which it is the source, and not the product. Herbert Spencer prefers to bring in *physiological units*.

Whence comes sensation? There was a moment when sensation pleasurable or painful was felt for the first time in the universe. Was this at the beginning? If so, one wonders how the sentient substance came through the heat, where, so far as we can judge, it must have been suffering intolerable anguish without the power of relieving itself by self-destruction.

Had this protoplasm self-consciousness? I rather think that neither Prof. Huxley nor Prof. Tyndall would say that it had. Animals from the very first have sensations, and also, at least the higher ones, ideas and very curious instincts, by which they make provision for coming evils of which they can have no conception. Finally, in the last of the unnumbered ages we have man with his intelligence, his conscience and free-will, all attested by consciousness. Will evolutionists pretend that on any rational or inductive principle they can tell how these new powers came into being and into action? When the book of Genesis tells us how these agencies did come in, and in particular how man appeared, science has and can have no facts to lead us to discredit it.

3. *There is Final Cause in Nature.*—Laplace, a great mathematician but not a great philosopher, imagined that, when we have discovered an efficient, it is not necessary to seek for a final cause. Aristotle, with a much more enlarged conception of the nature of the universe, maintained that we are to seek for both these causes—and for two others besides, the material and the formal. The fact is, that final causes presuppose efficient causes; and the efficient causes effect, by their coöperation, the final cause. We argue final cause, that is design, from the collocation of efficient causes to promote an evident end, say the ear to hear and the eye to see. The doctrine of development does not undermine or in any way interfere with the argument from design. This was asserted by Hugh Miller when the "Vestiges of Creation" was published, and has been gracefully illustrated and defended by Prof. Asa Gray in his pleasant book, "Darwiniana." When we argue that a watch has had a maker, we do not suppose it necessary that the watch should have been made by an immediate fiat of the mechanic. We so infer, because we discover agents combined to produce a particular effect, and the combination of these may have taken days or weeks of patient labor. So, the fact that the present adaptations and forms of the plant and animal may have been produced by a great number of antecedents, acting through ages, does not show that there is no design, but rather proves that there has been a bountiful end contemplated all along, and effected by a long process. Prof. Huxley, in the opening of his last lecture, has expressed his admiration—an admiration with which I thoroughly sympathize—of the structure of the horse: "The horse is in many ways a most remarkable animal, inasmuch as it presents us with an example of one of the most perfect pieces of machinery in the animal kingdom. In fact, among mammalia it cannot be said that there is any locomotive so perfectly adapted to its purpose, doing so much work with so small a quantity of fuel, as this animal, the horse." He speaks of the beauty of the animal arising "from the perfect balance of his parts and the rhythm and perfection of their action. Its locomotive apparatus is, as you are

aware, resident in its slender fore and hind legs, which are flexible and elastic levers, capable of being moved by very heavy muscles. And in order to supply the engines that work these levers—the muscles—with the force they expend, the horse is provided with a very perfect feeding apparatus and very perfect digestive apparatus." In all these things being *provided*—the phrase used by Huxley, though he has no right to use it—there is evidence of purpose, and this is not diminished, but rather increased, by the fact that the animal has been thus perfected by a long descent from an ancient progenitor. The argument of Paley and of the Bridgewater Treatises, derived from the bones and muscles of animals, and from the adjustments in every part of Nature, is as valid and convincing as ever. I believe Prof. Huxley admits this. I discover adaptation and contrivance, not only in the products but in the very process of development. Viewed in this light, development may, in the hands of a new Paley, furnish further and very striking cases of design. For, in order to the success of the process, there is often need of coördinated structure, that is, of a structure in which a number of parts are adapted to each other. My friend Mr. Joseph J. Murphy has supplied us with an instance in the case of the two nervous connections of the iris of the eye. "One of its nerves has its root in the brain, and contracts the pupil under the stimulus of light; the other has its root in the sympathetic ganglia, and opens the pupil again when the intensity of light is diminished. It is obviously impossible that the efficiency of either of these two nerves could be increased separately; they will not be improved at all unless they are improved together; and this, on Darwin's principles, can only be done by means of accidental favorable circumstances occurring in both at once. But such coincidences are so improbable that they may be left out of account as if they were impossible." I do not agree with Mr. Murphy in thinking that such an instance tells against Darwin; but I think the coincidence shows a preordained arrangement, and such coincidences are found in nearly every case of development, thus showing the need of coöperation and contrivance in the very developing process. It is to be observed that evolution, vegetable and animal, and natural selection, are not simple properties of matter like gravitation and chemical affinity. They imply the concurrence of an immense number of agents, mechanical, chemical, electric, galvanic; and Darwin adds pangenesis, and Spencer physiological units. In the concurrence and coöperation of all these to develop the plant and animal, I see proof of purpose; and in the culmination of the whole in the perfect forms of the higher animated beings, I discover a guiding intelligence which designed the end from the beginning.

4. *There are Typical Forms in Nature.*—It is now twenty years since, in conjunction with Dr. Dickie, I wrote "Typical Forms and Special Ends in Creation," in which I showed that there was not

only final cause, but a designed general order in Nature. When I composed that work I was filled with admiration of the discoveries made by Goethe and Oken, by Owen and Agassiz, as to the beautiful "forms" in Nature. Some may think that the more recent doctrine of development has made that treatise obsolete. I admit that these late discoveries might require me in some places to change my mode of expression; and the time has scarcely arrived for rewriting that book, and will not arrive till Darwin's doctrine and Owen's doctrine are more thoroughly adjusted. But, meanwhile, the argument is as valid as it ever was, and proves that there is a designed order and beauty in Nature, the design being not less evident because the order and beauty have been brought about by a process of development. This has been shown fully and satisfactorily by St. George Mivart in a recent article in the *Contemporary Review*, entitled "Likenesses or Philosophical Anatomy," in which he writes in the same way as I did of homologies, and shows that many of these cannot be explained by development or by a descent from a common parentage. He shows that "there are likenesses between different animals and different parts of the same animal which a theory of common descent cannot explain." He specifies instances of lateral, vertical, and serial homology, such as the vertebræ which make up the backbone, all similar, and the likeness between "the thigh, leg, and foot, of the lower limb, evidently more or less repeating the upper arm, arm, and hand, of the upper limb." I am inclined to argue that there is evidence of design in homologies which may have been produced by descent, as when we see the pectoral limb of the horse, the whale, and the bird—whether fore-leg, paddle, or wing—formed on one type, though turned to very different uses. All that Owen and Agassiz have said about the anticipations and the prophecies in Nature may be acknowledged as true, even by those who hold that they have been produced by development. I do believe that these old horse-like forms were preparations for the horse now living. The efficient cause may have been development, but the formal cause (to use Aristotle's phrase) is the perfected animal. We cannot allow this evolution doctrine to shear Nature of its grandeurs, nor, we may add, morality of its binding obligations or the universe of its God. Mr. Mivart concludes: "The teaching of what we believe to be true philosophy is that the types shadowed forth to our intellects by material existences are copies of divine originals, and correspond to prototypal ideas in God."

I close this article with remarking that these views bring Nature and revelation, geology and genesis, into harmony.

The Book of God begins at the beginning—with Genesis, the generation of all things. Science does not seem to tell us of a beginning. The Bible opens, "In the beginning God created the heavens and the earth." It tells us that there were an order and a progression in the generation of our world. First, there is an original creation.

Then the earth is "without form," without the order which it subsequently assumed; and "void," that is, without inhabitant. Light appears, and an alternation of day and night. There is a separation of the lighter matter from the grosser, of the aërial expanse from the earth proper. Then a separation of the sea from the land. Life now appears, and we have grass and trees. As yet the sun and moon have not appeared as formed bodies. Now, on the fourth day, they might be seen, and become dividers of times and regulators of seasons. All this is in accordance with science, which says that the earth is older than the sun; that the earth was formed out of an original matter and that there must have been light before the sun was condensed into its present form. Animals now appear first in the waters, swarming creatures and fishes, then reptiles and birds. On the sixth day we have animals—herbivorous and carnivorous. Finally, we have man. All this is very much the same order as is disclosed in geology, and was written there in that volume three thousand years before geology made its discoveries.

But we are most concerned with what, after all, is the most important to us, and that is the creation of man. There is a twofold record, the parts not contradictory but supplementary the one of the other. Chapter ii. 7: "And the Lord God formed man of the dust of the ground, and breathed into his nostrils the breath of life, and he became a living soul." This is expanded in a passage full of meaning: Psalm exxxix. 15, "My substance was not hid from thee when I was made in secret and curiously wrought in the lowest parts of the earth," seeming to indicate a process and a preparation; "thine eyes did see my substance being yet imperfect, and in thy book all my members were written while yet there was none of them." Such is the one side, the animal side. But then we have the other side, chapter i. 26: "And God said, Let us make man in our image, after our image, after our likeness. So God created man in his own image, in the image of God created he them." All this corresponds to our experience. We feel that we have an animal part cleaving to the dust, and allying us to the brutes. But we feel also that we have a divine nature, a power of distinguishing between good and evil, a longing for something higher, a seeking after God. The Bible tells, thirdly, that this image of God has been defaced. These truths have been combined in an eloquent passage by the profound Pascal: "The greatness and the misery of man being alike conspicuous, religion, in order to be true, must necessarily teach us that he has in himself some noble principles of greatness, and at the same time some profound source of misery. . . . The philosophers never furnish men with sentiments suitable to these two states. They inculcated a notion either of absolute grandeur or of hopeless degradation, neither of which is the true condition of man. . . . So manifest is it that we were once in a state of perfection from which we are now unhappily fallen. It is astonishing

that the mystery which is farthest removed from our knowledge—I mean the transmission of original sin—should be that without which we can have no true knowledge of ourselves. It is in this abyss that the clew to our condition takes its turnings and windings, insomuch that man is more incomprehensible without this mystery than this mystery is incomprehensible to man."

SKETCH OF DR. ARNOTT.

AMONG the agencies for the diffusion of the knowledge of physics and the taste for its study in the past generation, few were more effective and successful than "The Elements of Physics," a treatise for schools, by the author whose portrait will be found in the present number of the MONTHLY. It was a work in many respects of peculiar and remarkable excellence, from the felicitous treatment of the subject, the fullness and aptness of illustration, the pleasant and attractive style, and what may be called the practicalness of the book, or the prominence it gave to the exposition of familiar phenomena. Many students of both sexes in our higher schools received a bent in the direction of scientific study from the use of this text-book, which lasted through life; and, as a new edition of the volume is about to appear, brought up to the time by judicious and able editors, there are many who would like to know something about the personal character and life of the author.

NEIL ARNOTT was born on the 15th of May, 1788, at Arbroath, in Scotland. On his father's side he was descended from a Lowland family, and his mother was the daughter of a Highland clan. His youth was passed at Dysart, near Montrose. At the age of ten he became a pupil in the Aberdeen Grammar-School, where he remained the next three years.

In consequence of having been successful at the Bursary competition at Marischal College, in 1801, he became a student there, and completed the regular course, obtaining the degree of M. A. in his seventeenth year. It was during his third year in college, under the admirable instruction of Prof. Copland, that his mind was directed to natural philosophy, which henceforth became his favorite study. He chose medicine as his profession, and went through the medical course at Aberdeen. For the purpose of completing his studies, he went to London in 1806, and became a pupil in St. George's Hospital, under Sir Everard Home. Through the influence of the latter, he was appointed surgeon in the East India Company, where he gained valuable experience for his after-work. Having settled in London in 1811, he not only obtained large success as a medical practitioner, but at the same time was collecting materials for his future work on "Physics." In 1815 he was appointed physician to the French embassy, and after-