EVIDENCE OF DESIGN.

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The Evidence afforded by the Order and Adaptations in Nature to the Existence of a God.

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BY

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The Evidence Afforded by the Order and Adaptations in Nature to the Existence of a God.

THE writer having undertaken the elucidation of this comprehensive and important subject, in consequence of the inability from indisposition of the Rev. Charles Pritchard to fulfil that duty, he cannot but express his regret that the mantle of so distinguished a divine and philosopher should not have fallen on worthier shoulders than his own.

In the consideration of this subject it is not proposed to enter into any metaphysical disquisitions, since the "order and adaptations in nature" are physical questions; and in the metaphysical treatment of such questions the writer has not much confidence. It has been stated* that there are metaphysical difficulties in the summation of infinite series, and in the theories of ultimate ratios, and of impossible quantities: if so, the difficulties must lie, not in the principles themselves

* Transactions of the Victoria Institute.

but in their metaphysical treatment, because on the validity of these principles rests our knowledge of the grandest cosmical phenomena; such for example as the accurate prediction of eclipses, and the approximate determination of the place and magnitude of a large but hitherto unknown planet, from the observed disturbance of the remotest previously known member of the solar system. It is proposed rather to illustrate the subject by a careful observation of facts, and by the obvious inferences that may be drawn from them.

The subject naturally branches off in two directions; first, the order, and secondly, the adaptations in nature, both of which may be pursued far beyond the possible limits of this address. As illustrations of infinite wisdom may be taken, firstly, the gradual and progressive development of the earth, and the adaptation of its successive denizens to the circumstances under which they existed; secondly, the correlation of the materials; and thirdly, the correlation of the powers of nature.

I. When we contemplate a fossil bone or shell, which has lain buried it may be some thousands of feet below the earth's surface, or embedded in the solid rock that may have been by some vast convulsion heaved up to a similar height above it, we are led irresistibly to one of two conclusions: either that there has been (not to speak it disrespectfully) a sportive exercise of creative power, and that these portions of matter, bearing all the physical characters of what they represent, were never really associated with animal life; or otherwise, that they must be received as evidences of animal existence at very remote periods of time; and if the teachings of Geology and Palæontology be admitted, it must likewise be admitted that the Mosaic account of the creation is not susceptible of a literal interpretation.

Let us take a single illustration: on some elevated mountain range we meet with a bed of conglomerate, consisting of water-rolled stones cemented together; on breaking out one of these, it is found to contain organic remains, the shells of marine mollusca. Now what a vast series of cosmical changes does this represent! This shell must have been deposited in an ocean bed, which after an unknown period of time became consolidated into a rock; this by some subsequent great convulsion must have been broken up into fragments, and these fragments subsequently rounded by long-continued attrition, probably by tidal action on the sea-shore. These rounded stones, again, must have been cemented together by processes which, so far as can be judged from existing known facts, must have occupied vast periods of time, and the stratum thus formed must have been, by another violent convulsion of nature, upheaved into the position in which we met with it, or left exposed by denudation and the wearing away resulting from long-continued glacial or aqueous action.

It would appear then that the surface of our globe has been adapted to the exigencies of its present inhabitants not by any sudden act of creation, but by a gradual and progressive development, requiring countless ages for its accomplishment; and that as we descend in the order of strata that have successively formed a part of the earth's surface, the type of organization is generally successively lower, and also generally more and more remote from existing or more recent types: from these facts it may not unreasonably be inferred that the beneficence of the Creator has ever been exemplified in adapting the organization of His creatures to the conditions and circumstances under which they existed.

But a new theory of successive development has recently been promulgated, the obvious tendency of which is to supersede the necessity of creative intelligence; although, perhaps, the author of the theory of "Natural Selection," and probably some of his followers, may not be disposed to admit the validity of this inference. The theory of natural selection assumes that advances in development have taken place not by design, but by accident, or the force of circumstances, and that in the struggle for existence the individuals evincing an imperfect development have been annihilated; and thus that advanced development has ever held its own against inferiority, until existing perfection was attained; and as a crowning point, the theory does not exclude the development of man from the lower animals. If then man has been "developed" from a jelly-fish, or some other equally low type of organization, this theory needs only to be coupled with that of spontaneous generation (which assumes that some of the lowest types of organic life may be spontaneously developed from inorganic matter), and the necessity of an omnipotent Creator is altogether superseded! These theories have, however, one important point in common, namely, that they are alike destitute of any substantial foundation in fact: if only sufficient care be taken to exclude the invisible germs of organization with which the atmosphere is unquestionably loaded, no organisms are developed from the admixture of the most suitable materials; and on the other hand, of the countless missing links of imperfect development not a trace has ever been found. The very term "Natural Selection," by which is meant *selection* without *volition*, is self-contradictory, for the term "Selection" not only "seems to imply" (as Mr. Darwin admits), but actually does imply "conscious choice," and can imply nothing else.

In order to bridge over this admitted preliminary difficulty, Mr. Darwin quotes the intended explanatory remark of Professor Huxley, that "when the wind heaps up sand-dunes, it sifts and *unconsciously selects* from the gravel on the beach grains of sand of equal size."

Now this from so professedly close a reasoner as Mr. Huxley is rather surprising. What is the fact?

Both masses and particles, stones and grains of sand, that the retiring waves chance to have left at the surface, are alike acted upon by gravitation and by wind-pressure. But the amount of gravitation or weight-pressure depends upon mass, while the amount of wind-pressure depends upon surface ; and the amount of surface is increased by subdivision or extension, without any increase of mass, as for example the surface of an apple is increased by slicing, or that of a sovereign by beating it into gold-leaf. But it happens that in the stones vertical gravitation beats horizontal wind-pressure, and they remain behind, while in the grains of sand wind-pressure beats gravitation, and they are carried away, as the gold-leaf would be if scattered amongst a heap of sovereigns ; there is, therefore, no more sense in imputing "selection" to the wind, than to gravitation; none in fact in imputing it to either. If, moreover, the scraps of a torn-up love-letter happened to have been scattered on the beach, the wind would have probably made a further " selection," and instead of leaving them exposed on the dune, would most considerately have wafted them to some more secluded spot. Mr. Huxley might with perfect propriety have written, " The wind unconsciously *separates* from the gravel on the beach grains of sand," etc., but that expression would not have answered his purpose.

When Mr. Darwin proceeds to remark, "For brevity's sake I sometimes speak of natural selection as an intelligent power, in the same way as astronomers speak of the attraction of gravity ruling the movements of the planets," he cannot for a moment imagine that any one, astronomer or otherwise, imputes intelligence to gravitation. Mr. Darwin should remember that

> . . . . . Brevis esse laboro
> Obscurus fio ;

and if he had written, "for obscuration's sake," he would probably have been much nearer the mark.

The crowning triumph of "natural selection," in which the immeasurable chasm existing between the monkey and the man is assumed to be bridged over by accident and chance-medley, is the only point of that theory that need be further noticed. A belief in the progressive development of man from any inferior animal whatever is absolutely incompatible with a belief of the existence in man of an immortal spirit, for by no conceivable process can that which is essentially not material be developed from any combination of mere material elements. It is nowhere stated of any inferior animal that "God breathed into his nostrils the breath of lives" (not life, as in the authorized version; the revisers will, it is hoped, notice this); and it may not unreasonably be assumed that the plural noun *chayim** stands in the same relation to man's tripartite nature, that *elohim* does to the tripartite existence of the Godhead.

* It might seem pedantic to insert the Hebrew characters.

That the various orders of animal and vegetable existence in an ascending scale of organization might have been formed by a countless succession of almost imperceptible changes, if such had been the will of the Almighty, cannot for a moment be denied; but that any such course of events could have happened *independently of that will*, appears to be inconceivable. Nor is there any satisfactory evidence that such has actually been the course of nature; for admirably adapted as is the organization of the various orders and genera to the condition and circumstances of their individual existence, no examples have ever been met with intermediate between two genera, and imperfectly adapted to fulfil the conditions of either; and even in the few instances in which individuals have been obtained by cross-breeding which exhibit the mixed characteristics of two species of the same genus, they have invariably been found to be infertile, and incapable of originating a progeny exhibiting their own intermediate character. The only known facts that give the slightest countenance to the theory of natural or unintentioned selection are the results of intentional selection in varying to a certain extent the peculiar characteristics of different varieties of the same species, notably for example in the varieties of the pigeon tribe; but how slender and insecure a foundation is this for the huge superstructure of groundless hypothesis that has been raised upon it!

A valid argument against the supposed progressive change of organisation may be found in the persistence of some of the lowest types through countless ages of pre-historic time. For example, the white calcareous mud that forms the bed of the greatest ocean-depths is found to consist almost entirely of the shells of minute foraminifera ; and little doubt can exist that this mud constitutes, by slow and gradual consolidation, a progressive chalk formation ; for if a small portion be taken from any chalk stratum, and carefully brushed asunder under water, it is found to consist of exactly the same organic elements as the ocean mud in question.

II. The extreme simplicity of the ultimate elements which constitute all organized beings, and the endless variety of the proximate elements, arising from different combinations of the former, which serve to build up the animal and vegetable tissues, may well be cited as an illustration of the infinite wisdom by which such arrangements were established. The four elements, oxygen, hydrogen, nitrogen, and carbon, constitute the bulk of organization. The chief constituents of vegetable tissue are oxygen, hydrogen, and carbon, or, it may be said, water and carbon, as the oxygen and hydrogen exist in the same proportion as in water ; and various proportions of these constitute the proximate elements of vegetable tissue, such as starch, gum, sugar, glucose, and lignine, or woody-fibre, as may be shown by pouring a little strong sulphuric acid on a small portion of sugar : the acid will, by its stronger affinity, abstract the water, and leave a black spongy mass of carbon behind. Nitrogen enters sparingly into the constitution of the vegetable tissues, but almost universally into that of the animal tissues. The power of vegetable life in combining the inorganic elements, and thus preparing them for a higher state of organization in animal development, may likewise be noticed; but this power is wholly wanting in animals. Thus an important function may perhaps be ascribed to some of the humblest members of the animal economy; the despised earthworm, for example, is employed in continually reclaiming to a higher state of organization the effete vegetable matters on which it feeds, that are fast relapsing to the inorganic world.

One cannot but be struck by the simplicity of the arrangement by which carbon and water, elements of both earth and air, are combined into the various materials of vegetable tissue; and, moreover, that these proximate elements are so readily interchangeable by merely slight variations in the relative proportions of carbon and water, as, for example, the conversion of starch into sugar by the agency of warmth and moisture only, in the process of converting barley into malt, and of acid into sugar in the ripening of fruit. It may also be stated that, while animals are incapable of combining for their own nutrition the inorganic elements, they are capable of assimilating and drawing nutriment from those elements when already combined in the formation of vegetable tissues. And the same simplicity of construction, but variety in design, marks the building up of animal tissues; they are mostly slight modifications of a basis called protein, which is composed of oxygen, hydrogen, nitrogen, and carbon in certain definite proportions.

As remarkable compensatory actions, it may be stated that the combustion of carbon, or, in other words, its conversion into carbonic acid by combination with oxygen, is the chief source of that heat which is essential to the due discharge of the functions of the higher animals; while, on the other hand, the reduction of carbonic acid, and the corresponding evolution of oxygen, is constantly going on in the development of the vegetable kingdom.

III. Recent scientific research has pointed out the harmonious correlation and mutual convertibility of the various powers or energies of nature, such as light, heat, electricity, and magnetism; and likewise the definite convertibility of heat and mechanical work: and these views have rendered much more intelligible the mode in which these several agents become subservient to the exigencies of organic development.

Thus, for example, while the combustion, or, in other words, oxidation of the farinaceous and fatty elements of food continuously supplies the animal economy with the amount of heat which is necessary for the due maintenance of all its varied functions, a portion of this heat is transformed into dynamic energy in the muscles, and a further portion probably into electricity in the nervous system; for the mutual convertibility of heat and electricity is a well-ascertained fact. Moreover, the proceeds of combustion, the same as in our fire, candle, or gas-burner, namely, water and carbonic acid, are continually eliminated from the system, and restored to the inorganic world by the agency of the skin and lungs, to be again deoxidized in the development of the vegetable economy. It appears to be far from improbable that the energy which reaches the eye as light paints its photographic impression on the retina as chemical action, and then travels to the brain in the form of electricity. Again, the influences of light and heat in promoting, and of their absence in restraining animal development are too notorious to require any specific illustration; but do not these considerations lead irresistibly any unprejudiced mind to the conclusion that indeed we are fearfully and wonderfully made? and it is much to be regretted that the great principle of the Conservation of Energy should ever have been held to countenance the views of those who would supersede the necessity of creative intelligence, instead of perceiving in that theory only additional evidence of the infinite wisdom of the Creator.

As one of the leading objects of the Society at whose instance this address is made is to counteract any apparently irreligious tendency in the teachings of modern science, the writer feels bound to notice some passages in a recent work by Professor Tyndall, entitled "Fragments of Science for Unscientific People," as being eminently likely to mislead some of those for whose edification it is especially designed. A grievous error appears to underlie two of the essays in this work, those on "Matter and Force" and on "Scientific Materialism," in the tacit admission of an identity of causation in the structural development of inorganic formations, and of organised beings. In the former of these essays, the substance of a lecture addressed to the working men of Dundee, during the meeting of the British Association in September, 1867, after showing the quasi-structural arrangement of iron filings scattered on a plate of glass placed over the poles of a magnet, and the laminated leaf-like crystals of silver and lead formed by gradual deposition from solutions of their respective salts, and after pointing out the arborescent forms of crystals formed by the evaporation of their solutions thinly spread on a plate of glass, and of the ice-crystals formed on our window-panes in the winter, the author asks (p. 86), "What is the vegetable world itself, but the result of the complex play of these molecular forces?" But he suggests no reply. Again, after alluding to the formation of vegetable tissues by the decomposition of carbonic acid, the union of the carbon with the elements of water, and the evolution of the oxygen, under the influence of solar radiation, he proceeds to state (p. 87), "Just as the molecular attractions of the silver and the lead found expression in the production of those branching forms seen in our experiments, so do the molecular attractions of liberated carbon and hydrogen find expression in the architecture of grasses, plants, and trees." This is undoubtedly true, but it is not the *whole truth;* and the author surely ought to remember that the "suppressio veri" is sometimes equivalent to the "suggestio falsi."

The error above alluded to consists in ignoring throughout these essays the indispensable influence of a germ derived from a precisely similar organism in determining the organisation of any individual plant or animal. While the atoms of lead or silver, from whatever compound they may be gradually disengaged, will in obedience to their inherent polar forces respectively form laminæ, the edges of which are inclined to each other at invariable angles, the same elements derived from the same earth, air, and water, as for example in a field or garden, will constitute an indefinite number of different vegetable organisms, the formation of each individual kind being determined *solely* by the influence of a pre-existing germ derived from the same kind: and thus while mere molecular forces may be considered as alike the immediate cause of the formation of the metallic crystals, and of the proximate elements of vegetable tissue, those forces are not the immediate cause of the formation of any particular organism.

Again, in p. 91, the author writes: "Trees grow, and so do men and horses; and here we have new power incessantly introduced upon the earth. But its source, as I have already stated, is the sun; for he it is who separates the carbon from the oxygen of the carbonic acid, and thus enables them to recombine." Now this is not strictly true; for if a stoppered bottle be filled with carbonic acid, probably no amount of exposure to solar rays would have any effect in producing decomposition; all that the solar rays can do is, to impart to the molecules of carbonic acid such an amount of vibratory motion as enables the vital energy of the leaf-cell more readily to tear the atoms asunder, appropriating the carbon to its own nutrition, and rejecting the oxygen;—here again the influence of vitality is ignored.

No formation of the proximate elements of vegetable tissue is known to take place independently of the influence of previous organisation; while, on the other hand, the development of plant-life, imperfect and abnormal though it may be in some cases, is met with when solar radiation is excluded; it therefore seems to be altogether illogical to put forward solar radiation as the sole, or even the main, antecedent of vital development.

The author subsequently proceeds to observe:

"Some estimable persons very possibly shrink from accepting these statements; they may be frightened by their apparent tendency towards what is called materialism—a word which to many minds expresses something very dreadful. But it ought to be known and avowed that the physical philosopher, as such, must be a pure materialist."

If by materialism is meant the investigation of the laws of matter, as magnetism (as a science) is the investigation of the laws of magnetic force, it may safely be conceded as a truism that the physicist, as such, must be a pure materialist; but if materialism be taken in its ordinary acceptation to mean a denial of the exercise of either creative power or superintending intelligence in the formation and development of the universe, then it is most emphatically denied that "the physical philosopher, as such, must be a pure materialist;" and if the author persists in the use of a common phrase in a very uncommon sense, he must not be surprised if his motive is sometimes misunderstood.

A little further on the author states: "Depend upon it, if a chemist, by bringing the proper materials together, in a retort or crucible, could make a baby, he would do it."—No doubt he would; and if you or I could jump over the moon, we should be proud of showing our agility in so doing; but the fact is, we cannot — the principle of the conservation of energy forbids it: for if all the combustible material in our frame were instantly burnt up, and the heat produced converted into energy, the resulting amount would be wholly insufficient for the purpose; and the author's hypothetical baby-making is not less antagonistic to the universal law—

"Omne vivum ex ovo."

The germ is as indispensable as the constituent material atoms in the development of a living organism.

To identify as much as possible the forces conducing to the development of organic and of inorganic structures, may be presumed to be an object of "Scientific Materialism;" but the Author has, in p. 116, endeavoured to support this conclusion by an erroneous analogy, namely, that the phenomena observed on transmitting polarized light through starch grains are "similar to those noticed in crystals." In the crystals, undoubtedly, the molecules are "self-posited" in obedience to definite polar forces; and in order that they may influence a beam of polarized light, it is necessary that these forces be unequal in at least two of three perpendicular directions in each molecule, and if the crystal be regularly formed, the disturbance of polarized light is the same in all parts of the same slice; but in starch grains, as in quill, horn, hoof, and all other organic substances, that disturbance is due to molecular *strain* consequent on desiccation, and not to definite aggregation, just as is in unannealed glass it is due to the molecular strain consequent on sudden cooling; in fact, it is well known that any molecular strain upon a plate of glass, such as that produced by bending or compressing it, or throwing it into a state of sonorous vibration, will confer upon it the power of de-polarization. That the de-polarizing power of a plate of unannealed glass is not due to a polar aggregation of its molecules, as in a crystal, is further evident from this, that if a square plate be ground into a round one, and then the circumference of that into a scolloped outline, the visible influence of the plate on a polarized beam will in the three cases be very different, and not as in the crystal, uniform.

On the slender analogy just alluded to the author, in p. 116, bases this dogma of "Scientific Materialism":— "But if in the case of crystals you have rejected this notion of our external architect, I think you are bound to reject it now, and to conclude that the molecules of corn are self-posited by the forces with which they act upon each other. It would be poor philosophy to invoke an external agent in the one case and to reject it in the other."

The author's inference is plainly this, that the formation of the crystal and of the starch-granule is solely due to the action of atomic force. But if this be so, how happens it that while crystals of the same substance, from whatever source derived, present the same characteristics of external form and internal structure, the starch-granules of wheat, of tous-les-mois, and of cassava, exhibit marked but invariable differences of structure, as shown by their optical characters, although composed of the same atoms, combined in the same proportions? Just for the same reason that the plants in which they were formed derive their respective characteristics, not from the inorganic forces of the atoms of which they are composed, but from the organic power of the germ derived from a precisely similar organism, which, while it calls into play the inorganic atomic forces, at the same time determines the whole course of subsequent structural development; as the tiny electric spark actuates those atomic attractions by means of which the resistless force of the mine or the torpedo is developed. How mysterious is it that the vital power determining the reproduction of parental characteristics of form and feature should once have been locked up in a vesicle of microscopic dimensions!

But if the influence of a germ be indispensable in the organisation of life, whence came the first germs, or the first germ-producing organism? While materialism will answer, "I cannot tell," it is to be hoped that the unbiassed convictions of reason, and the promptings of our moral sense, will ever point to the infinite power, wisdom, and goodness of the Creator. Thus it appears that "Scientific Materialism" is not more scientific, because not more logical, than other forms of materialism with which we were previously acquainted.

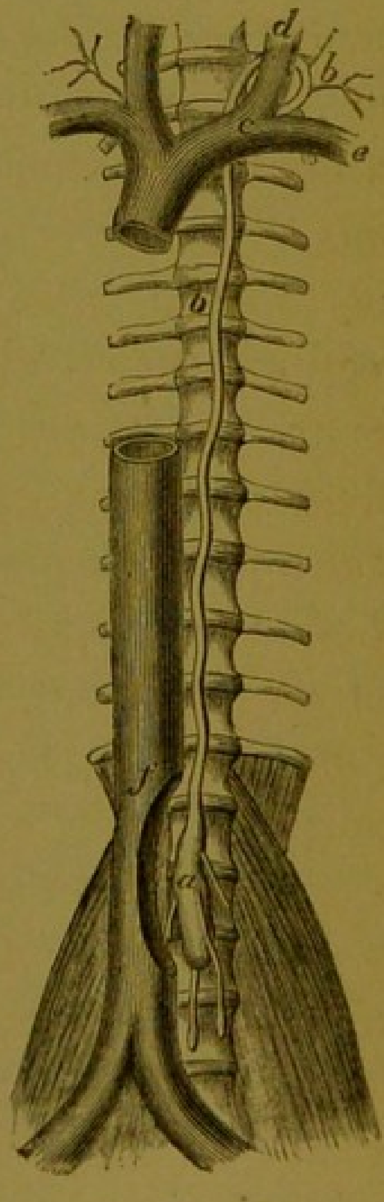
The author may perhaps, with some show of reason, demur to this criticism on the actions of polarized light, on the ground that as he is avowedly addressing his arguments to "unscientific people" it would have been futile to enter into the differences between the black cross as seen in a starch granule and in a slice of calcite : very good, but if analogy of structure be made use of as an argument in favour of identity of causation, then the strength of the argument depends on the strength of the analogy, and in that case we are bound to look into it, and to see how much it is really worth.

Having now cursorily considered some of the more striking indications of infinite wisdom as manifested in the order of nature, it remains to illustrate the same attribute of the Creator by the obvious adaptation of things created to the functions they are designed to fulfil. The careful observer cannot but perceive that throughout the whole range of natural objects the admirable adaptations of means to ends are unlimited alike in their number and variety ; but it has appeared to the writer that some of the more special and recondite examples of adaptation are the farthest removed from the possibility of accidental formation, and therefore afford the most conclusive evidence of beneficent design. And in order to bring the subject within the reasonable limits of an address, it is proposed to confine attention to three points in the economy of man, the mechanism of the absorbent system, and of the organs of sight and hearing.

The Mechanism of the absorbent system.—In order to render this subject intelligible to a general audience it may be observed that whenever any organ of the body exercises its peculiar function, as, for example, a muscle in contracting, or the brain in thinking, a certain portion of the organ itself is used up by a process analogous to combustion, by which the amount of heat is generated that is equivalent to the work done by the muscle, and probably also to the amount of electrical action that takes place in the brain. This used material and all other kinds of effete matter require to be constantly removed from the animal economy, and for this purpose they are collected from every part by a system of vessels called absorbents. Moreover, the waste of the system demands constant renewal, and to effect this, nutriment is collected by absorbents from the inner surface of the alimentary canal. Both the materials for the repair of the system, and those requiring removal, are conveyed by these vessels into a common receptacle, whence the contents are emptied into the veins by a very peculiar mechanism, and carried into the general circulation of the blood. The mechanism of the absorbent vessels themselves is remarkable, and entirely different from that of any other system of vessels. The venous system commences from the union of the smallest or capillary vessels, into which the blood is constantly urged from the arterial system; and it is a note-worthy fact that in all classes of the animal kingdom the capillaries are of such diameter as just to allow the blood-particles to pass through them in single file, the blood-discs themselves varying very greatly in size in different tribes of animals. The smaller veins are formed by the coalition of capillaries, and the larger are continually formed by the coalition of the smaller, but it is only in the large venous trunks that any special valvular arrangement exists to prevent regurgitation of the blood; and as man was designed for the erect posture, as might be expected, the valves occur at shorter intervals in the lower extremities, in which the return of the blood to the heart is opposed, than in the upper portion of the frame, in which that return is assisted, by gravitation.

But the conditions of fluid-movement in the absorbent vessels are totally different; there is no *vis a tergo* to urge onward their contents, and their action, instead of being continuous, is intermittent, depending on the amount of fluid matter to be absorbed. Moreover, the absorbents are mainly dependent on the movements of the body for urging on their contents, and their structure is in complete accordance with their requirements. This structure may be roughly described as consisting of a succession of pear-shaped funnels, the nozzle of each being inserted into the wider end of the next, and these act as a continual succession of valves, by means of which all regurgitation of the fluid contents is prevented. A, in the following figure,

represents a portion of one of these vessels, and B the same laid open to show the valves.



The most signal instance of design is met with in the means by which the main absorbent trunk discharges its contents into the venous system. The absorbents from the greater portion of the frame pour their contents into the common receptacle *a*, and hence the duct, *b b*, mounts upwards towards the neck, and pours its contents into the venous system at *c*, the angle of juncture of two large veins, the jugular, *d*, and subclavian, *e*. Now if the communication between the chyle-receptacle and the adjacent venous trunk *f* had been first formed by any imaginary process of "natural selection," by any conceivable attraction or affinity between the fluid contents of the two vessels, they might have been expected to form their junction at the point of nearest proximity: but no;—the chyle-duct is found to pursue for some distance a nearly parallel course with the great vein, and then to mount upwards in order to reach the point at which it can empty itself into the venous system at the greatest mechanical advantage.

It was first shown experimentally by Bernouilli, and by the writer demonstrated geometrically,* that if a current of fluid be driven through a diverging tube, into which a smaller branch enters laterally, there is not only no tendency of the current to flow out through the lateral branch, but on the contrary, if its orifice be immersed in another fluid, a portion of the latter will actually be drawn in by the current in the larger tube; this fact may be demonstrated with very simple apparatus. And this effect takes place more energetically at the point of convergence of two tubes, as at *c* in the figure: this may be readily shown by a model in metallic pipes of the arrangement, through which a column of water may be urged with sufficient energy.

The Mechanism of the Eye next comes under our notice, and without attempting to enter into all the details of its wonderful and beautiful mechanism, which time forbids, it is desired specially to draw attention to the means by which the eye is adapted to the distinct vision of objects at different distances. In the interior of the eye a lens, analogous in its properties to an ordinary lens or magnifying glass, is placed between two chambers, the anterior of which is filled with a limpid fluid, the posterior with a somewhat

* Elements of Natural Philosophy, Ed. 1867, p. 239.

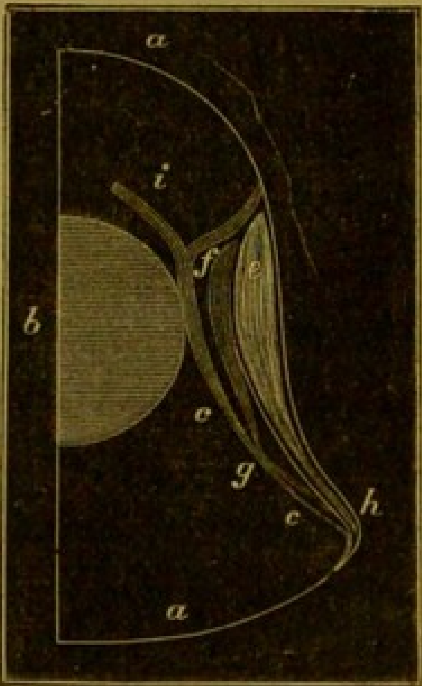
denser substance, the vitreous body. At the back of this is stretched a nervous membrane of exceedingly complicated structure, the retina, on which the impressions of all luminiferous vibratory motions are made.

It is the ordinary property of a lens that the rays falling upon it from any given point of an object are refracted in passing through the lens, and converge more or less accurately to some point on the opposite side of the lens; and these corresponding points are called conjugate foci: and it is further found, both practically and theoretically, that as the focus of the incident rays approaches the lens, that of the refracted rays recedes from it, and *vice versâ*. The normal condition of the eye is that when parallel rays, *i.e.*, rays proceeding from objects at indefinite distances, enter the eye, they are brought to a focus on the retina, and as the rays from each point of an object are collected on a corresponding point of the retina, it follows that a perfect image or picture of the object is traced upon the retina. If now the eye be directed to a near object, and there be no change in its internal arrangements, it is evident from what has preceded that the focal point of each cone of refracted rays from each point of the object will now fall behind the retina, and the image of each point of the object *on* the retina will no longer be a point, but a patch, and the perpetual overlapping of these patches is the source of all indistinct vision, not depending on any optical imperfection of the organ. How then is the distinct vision of near objects to be accomplished? By some internal change in the eye itself, by which the focus of each pencil of rays incident from a near object is brought forward, so as to fall exactly on the surface of the retina, and so form a distinct image of the object; this is termed the *accommodation* of the eye. But how is this effected? It may be effected either by increased convexity of the lens, arising either from internal action of its fibres, or from equatorial pressure, by which its focal length is shortened; or it may be effected by bringing the lens forward without any change in its focal length.

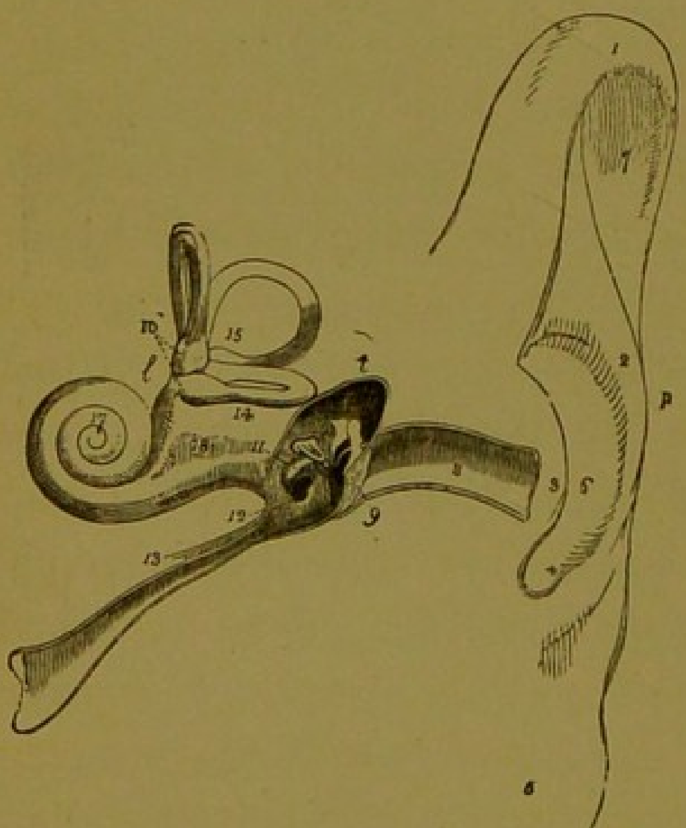
Now this is clearly not a voluntary action; so far from it, that the most eminent physiological authors are by no means agreed as to how it is accomplished. The writer believes himself to be in the minority in thinking that accommodation is effected by bringing the lens forward; and to explain how this may be effected in the human eye would require a more profound discussion of minute anatomical details than is consistent in a lecture addressed to a general audience; but examples of a much more readily intelligible action may be met with in the lower animals. The figure* represents half of an antero-posterior section of the eye of an eagle-owl, in which *a* is the transparent cornea, *b* the lens, *c c* the choroid membrane, *d* the retina, and *i* the iris. The lens is pretty firmly attached to the choroid: *e* is a section of the ring of osseous plates that surrounds the eye;

* Drawn *ad nat.* by Dr. R. J. Lee.

from the anterior edge of this ring of bone arises a funnel-shaped muscle *f*, which is inserted all round into the choroid at *g;* and from the same point, *g*, there passes down to the posterior margin of the ring of bone an elastic ligament, *g h*. It must be observed that the parts are here represented somewhat strained out of their natural position, in order that they may be distinctly seen: in the natural position the choroid, *c c*, lies close to the ring of bone *e*, separated from it only by the muscle, its tendon, and the elastic ligament. The function of this annular muscle, *f*, is clearly to bring forward the choroid, and with it the lens to which it is attached, and it is equally obvious that the function of the elastic ligament is to pull the lens back again into its normal position, when the muscle has ceased to act. The eagle-owl is a nocturnal as well as a carnivorous bird, and in order to fulfil its functions in securing its prey, requires rapid and accurate accommodation of the eye, for accomplishing which the eye is provided with an unusually powerful muscle. Can any one seriously maintain that these perfect adaptations of means to an end formed themselves, or resulted from the blind action of atomic force?



The Mechanism of the Ear.—In order to render intelligible some of the more recondite adaptations of this organ, the accidental formation of which is the most inconceivable, it is necessary briefly to premise the general mechanism. Sonorous vibrations impinge on the tympanum or drum of the ear, hence they are conveyed by a curious chain of minute bones to another membrane which closes a cavity filled with fluid, which constitutes the vestibule (as it is called) leading to two special receptive apparatuses abundantly supplied with nerve-filaments, the cochlea and



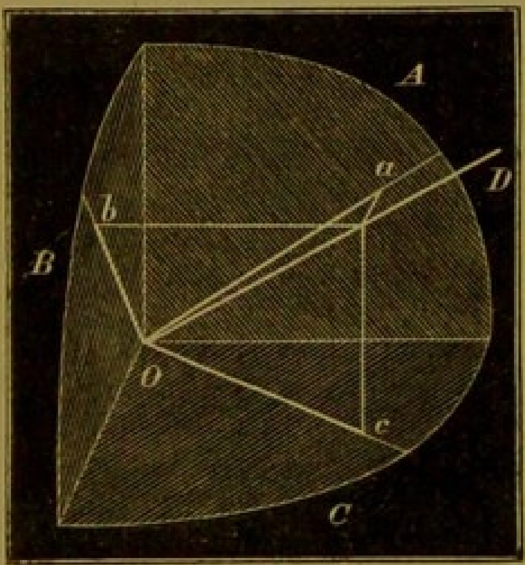
9. The tympanum.
10. The ossicles.
14. The vestibule, leading to
15. The three semicircular canals.
17. The cochlea.

the semicircular canals. These several parts will be seen in the diagram.*

* This figure is from Wilson's "Anatomist's Vade Mecum."

The cochlea in form resembles a snail-shell, the spiral chamber being divided into two parts by a membrane stretched across it, the transverse fibres of which are capable of being rendered more or less tense by a muscle extending throughout the length of the chamber. As the diameter of this spiral chamber decreases gradually from the base to the apex, it is obvious that the transverse fibres of the spiral lamina must also gradually decrease in length. On this membrane rest the free ends of a series of remarkable organs called the rods of Corti, placed parallel to each other like the keys of a manual, and their attached ends are embedded in nerve cells. There is little room for doubt that sounds of a given pitch, or frequency of vibration, specially affect a corresponding fibre of this membrane, (just as the shorter strings of a harp or piano correspond respectively to higher tones,) and that the nerve-tissue adjacent to the rod resting on this fibre *feels* the sonorous vibration, and transmits to the brain its perception of it: and thus that the special function of the cochlea is to appreciate the frequency of the vibrations, that is to say, the *pitch* of musical sounds, and also probably their *timbre* or *quality*. The mechanical means by which vibrations of given period are specially transmitted to the corresponding portion of the spiral lamina, have not yet been explained, but the writer is not without hope of being able to unravel this intricate question.

The three semicircular canals (each of which, however, comprises more than a semicircle) are chiefly remarkable for their *invariable* relative position; they are, without exception, found to lie in three planes, each of which is perpendicular to the other two; or in the language of geometry, in three rectangular co-ordinate planes. From the simplest geometrical considerations it follows, that if an impulse travel in the direction D O, the portions of that impulse which are



effective in the directions of three co-ordinate planes O A, O B, O C, will be proportional to *a* O, *b* O, *c* O respectively, the cosines of the angles which the direction of the impulse makes with the three planes. Moreover, it is a dynamical law that waves will retain their original direction, unless that direction be changed by reflection or refraction; consequently, if the nervous apparatus of the semicircular canals be capable of appreciating the relative intensities of the impulses communicated to each, which is without doubt the case, it is obvious that, by means of these canals, the ear can appreciate the direction from which sound proceeds.

The faculty of perceiving the direction of a sound, and hence the direction whence danger may be apprehended, must obviously be a much more wide-spread necessity in the animal economy than the faculty of discriminating tone and quality of sound ; accordingly, the perfect development of the semicircular canals is met with as low in the scale of organisation as the cartilaginous fishes, while in the cochlea and the ossicles we meet with various stages of progressive development, each obviously adapted to the exigences of the individual organism ; and especially in the fish and reptile tribes that do not emit vocal sounds, the construction of the auditory apparatus, apart from the semicircular canals, is exceedingly simple. Can any one really believe that all these admirable adaptations resulted from blind chance, or from the necessity of the case, unintentioned and undesigned ?

But the evidence of design in the ear does not end here ; and in order to render the sequel intelligible to those who are unacquainted with physiological details, it becomes necessary to briefly indicate the general relations of the nervous system. This consists of two distinct parts ; one, the cerebro-spinal system, comprising all nerves that terminate in the brain and spinal cord, which fulfils all the functions of perception and volition ; this system exists in all vertebrate animals, in an ascending scale of development up to man. The other, the ganglionic system, consisting of fibres terminating in nerve centres, or ganglia, distributed over various parts of the frame, but chiefly in two parallel rows arranged on either side of the central axis, or the vertebral column ; the office of this system is to fulfil the involuntary functions essential to the development and maintenance of animal life; this system is common to men and all kinds of animals, down to the slug, the worm, and the caterpillar.

It is an obvious necessity that the ear should possess some means of adaptation to the intensity of the vibrations reaching it, in order that while the feeblest sounds may be appreciated, its delicate mechanism may not be deranged by the most powerful ones; just as the eye is adapted to the intensity of incident light by the contraction and dilatation of the iris. For this purpose there is a little muscle by which the tympanic membrane can be tightened; a second by which is regulated the tension of the membrane which connects the base of the stapes, the innermost of the ossicles (so called from its stirrup-like shape), with the margin of the oval aperture in the wall of the vestibule; and a third muscle, or rather series of muscles, by which the tension of the spiral lamina of the cochlea is regulated. But how is this exquisite mechanism brought into play? how, in fact, is the ear itself informed of the adjustment required? The foremost member of the chain of ossicles is firmly attached to the tympanum, and is carried to and fro by its vibrations: proceeding laterally from this bone, and in a direction nearly parallel to the plane of the adjacent portion of the tympanum is a slender and taper bony filament, in its relative proportions resembling a lady's riding whip ; and immediately behind this slender process lies the tympanic nerve, a branch of the ganglionic system, which pursues a very tortuous course, for no other assignable reason than that of coming into relation with the filament of bone just mentioned. What happens then? The very first sound-wave that strikes on the tympanum makes, by means of this tiny bone, an impression of corresponding intensity on the nerve, which is flashed to an adjacent centre of nerve power, and the mandate to "make taut" or "let go," as the case may be, is returned and acted on, ere a second wave can impinge upon the tympanum.

The train of actions just described is altogether removed from the domain of the will; it is, moreover, so far from being obvious, that it is believed to have escaped the notice of every writer on physiology. If, then, the mere explanation so far taxes the powers of the human mind, what shall be said of the infinite wisdom by which the whole was designed? Well indeed may we be prompted to declare with the sacred Psalmist, "He that planted the ear, shall He not hear? or He that made the eye, shall He not see?" It would be far more unreasoning to believe that that unrivalled mechanism, the human frame, was self-developed, than to believe that if a "fortuitous concourse of atoms" of brass and steel, swept up from a workman's floor, were put into a bag and thoroughly well shaken, they would spontaneously evolve a first-rate chronometer.

If this experiment were made, and, as is highly probable, attended by failure, the advocate of undesigned evolution would probably exclaim, "Aye, but you have not shaken the bag long enough; if you will only shake on for countless æons, no reasonable doubt can be entertained that your efforts will ultimately be crowned with the happiest results. The course of development, you may reasonably anticipate, would probably be something of this kind: the atoms of brass and steel would respectively aggregate themselves into rounded masses, and these, when old enough to cut their teeth, would become wheels and pinions. As time rolls on, you must expect some examples of imperfect development; one, for example, without a main-spring, another without a balance, and a third without face and hands; but, never mind, pitch them back again into the bag, where they will, no doubt, 'perish in the struggle for existence,' and be shaken to pieces again, that their *disjecta membra* may re-form themselves more successfully. Moreover, if you want your chronometer to go on a diamond, and to be jewelled in eight or ten holes, you must put into the bag a little soot and a little pipe-clay."—Soot and pipe-clay, what good can they do?—"All the good in the world; we only want the material atoms, you know, and chance and plenty of time will enable their inherent powers to accomplish all the rest. The diamond, as you are aware, is only carbon, and in due course of time the carbon-atoms will rush into each other's embrace, and constitute little diamonds, which will grow bigger by accretion. I know that these carbon-atoms are very coy; no one has ever yet induced them to take the final step, but time, my friend,—time will work wonders. Again, the rubies for the holes are nothing more than alumina, with a small quantity of iron, and a trace of lime, which they can easily pick up; and pipe-clay is the handiest source of pure alumina that I can suggest to you."—Is not the unintentioned evolution of organised beings indefinitely more absurd, *à fortiori*, than this?

If any hearer or reader of this address should think that a little banter is out of place in so serious a subject, he may, with all due respect, be reminded of the opinion of a profound thinker of the olden time, that

"Ridiculum acri
Secius ac melius magnas plerumque secat res."

In conclusion, as the adaptation of means to beneficent ends, such as those which have been imperfectly described, are the more special and recondite, it may fairly be assumed that in the same proportion they bear the stronger evidence of the boundless wisdom and goodness of the Creator; well indeed may the devout believer exclaim with heartfelt gratitude,

"When all Thy mercies, O my God,
My raptured soul surveys,
Transported with the view, I'm lost
In wonder, love, and praise."