Original Communications.

I.—Life—Vitalists and Physicists, Teleology. By Robert Garner, F.R.C.S. Eng., F.L.S., &c.

The great and obvious difference in characteristics between every inorganic body, even the most specialised as a crystal, and the most simple organic being, leads, as it appears to most people, to the natural conclusion that they belong to two very different classes of objects, governed by forces very different from each other, or rather that the latter owe their endowments to a superadded one, though, indeed, they continue influenced to a certain extent by the purely physical forces, to which all matter whatever is more or less subject. We can imagine mere physical force, as molecular attraction, to form a crystal, but it appears incongruous, at least to many of us, to suppose that any physical force or forces can build up an infusorial, a polype, or a lichen. This last act we, for our part, refer to what appears as much entitled to a name as attraction or any other force—vitality or vital force; the action of which is indicated in such a way that there appears to be a wide difference between it and the action of such force as is seen to work in inorganic bodies. We can imagine bodies, or a world of bodies, not endowed with vital force or action, but cannot conceive them uninfluenced by the ordinary physical.

Though we cannot know what this force or endowment absolutely is, we can observe the peculiarities of its operation, and consequently, though essentially unknown, it is in its characteristics just as discoverable and as appreciable as other forces; it has, indeed, been said to be unappreciable to thought, whilst it appears to be the source of thought itself. If there is ever any difficulty in drawing the line of separation between the two kinds of objects living and non-living, it is only, in some cases, from their extreme minuteness. We may not always distinguish a monad from a molecule, or a bacterium from a fibre of dead matter, but commonly such a difficulty does not exist—there is no borderland between living and non-living objects. There is, however, a difficulty when we endeavour to draw the distinction between animal and vegetable life in its lowest forms. Hence the division into organic and inorganic bodies is more definite than that into animal, vegetable, and mineral.

If we were asked what are the characteristics of living bodies, an answer might be given as follows. All organisms have a susceptibility as regards their environment, due to the necessity of their interstitial growth—a differentiation of structure, likewise, as the environment becomes more complicated, (though, at the same time, this is not to admit that this complication can *per se* produce this differentiation, and one would even prefer to go back to an *archeus* or *vis insita* instead)—motility or locomotion, especially in animals—a fixed duration of growth and life—a relation both to the past and the future, in origin and in the function of continuing their kind. Essentials for organisation are, 1st, that the matter of which organisms consist should be plastic, neither of extreme hardness nor too fluid; the enamel of the teeth, the shell of molluscs, or the silicated cuticle of grasses is extremely hard, but the living state is ceased in them; the blood, considered by John Hunter to have life, though fluid, is imperfectly so, and prone to solidify; 2nd, there is a limitation of elements, chemically speaking, though this limitation by no means implies that the secondary or proximate constituents are not of a very composite nature;[1] 3rd, the presence of water as a constituent; 4th, a capability of coagulation and solidification and their reverse.

The existence of a crystal is not endangered by the abstraction of a portion, and the portion broken off has the same qualities as the crystal from which it is taken, the same constituents, and no limitation as to duration; but a particle from the organic individual does not, except in the lower forms, or potentially in some cases, present the whole qualities, physical, chemical, and vital, which the individual organic body does. Attraction, molecular or chemical, with some such phenomenon as polarization, appears, as already observed, sufficiently to explain the formation and conservation of organic bodies, though crystallisation is one of the most curious of the effects of these simple causes; not so, as we take it, of organic objects. In the latter, cell-formation and cell-growth predominate; in the former, homogeneity and simple molecular attraction, with its results just mentioned.[2]

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[1] It has been said that the gulf between the organic and inorganic worlds has been bridged by the formation in the laboratory of certain of the proximate constituents of the former. The question is, what are the *true* constituents, and what *excrementitious* matters?

[2] We know of nothing in the inorganic world so like the effects of organization

In the case of organic bodies it becomes presumable, even from the excentric nature of the force which presides over their formation, a force as much entitled to the name *development* or *evolution* as any other formula which claims it, that in the main there will be an increasing perfection in organic existence, individually, collectively, or systematically, and through time; a fact obvious in embryology, in the anatomy and morphology of animals, and as far as we know in geological life-history; but it is an error to make this increasing perfection to consist in a concatenated or linear ascent through all orders or groups, rather than an arborescent one with frequent ramifications.

At the present day there are several physiological and philosophical questions connected with this subject, which, though in past times debated and afterwards forgotten or neglected, are afresh exciting interest, and this interest of a very absorbing nature. Such questions are the origin of life on the earth,—though any distinct origin is ignored by the disciples of evolution—the nature, or at least the relations of the vital force, and the cause or causes producing the increasing complication and variations in living beings. The interest of such questions becomes magnified when we find that their discussion may require us to renounce or modify our earliest impressions, or to doubt what we have previously considered as fair conclusions of our understandings.

With respect to the first point of those enumerated—the origin of life on the earth—whether it appears *de novo* and constantly, as regards its lowest forms (heterogenesis), or is only continued through the germs of preceding organisms (epigenesis), perhaps the less said at the present time the better, as the question is, we trust, as far as it can be, fairly *sub judice*.[1] To the present time the first doctrine has, we think, had the approval of many, and moreover, one can hardly understand how believers in evolution, to its full extent, can dispute it; for surely vital germs cannot be required where so little has to be accomplished, the objects so simple and minute, the agencies in other directions so efficient. We will only say, once for all, that if it be necessary to admit either heterogenesis, or the appearance of higher beings

as the dendritic infiltrations sometimes seen between blocks of mountain limestone, putting on the exact similitude of fossil algæ or fuci; but they can be well imitated by art. Professor Tyndall instances the snow-star or ice-flower, the lead tree, and the crystalline structure of cast iron as approaches to what is seen in organisation—phenomena which apparently are the concomitants of what is most antagonistic to organization—extreme cold, strong chemical action, and intense heat.

[1] The writer has been inclined to admit heterogenesis. His doubts of it arise as much from the fact that the minute organisms in question are not found in the morbid fluids of naturally closed sacs, as the ovarian cysts or the tunica vaginalis, as from any laboratory experiments.

on the earth by what has been called natural law, in contradistinction to special interference, it does not appear that there is anything in our professed historical cosmogeny to contravene such views.

Granting, what is commonly considered as proved by embryology, by the growth of the individual, by the supposed greater simplicity of organisms as we go back in geological time, or the reverse, their increasing complications as they succeed each other, that living beings in some way or other undergo a development from more simple incipient forms, we are again arrested, in the first place, with this question—What is the peculiarity of the matter or plasma of these forms on which depends the phenomena called vital, and which we, naturally at any rate, attribute to some intrinsic endowment quite different from what we notice in inanimate objects? We have already confessed that it is difficult or impossible to define this endowment in its supposed real nature, but appropriate to it the name life, vital force, or some such term. But we are told, with great force of language, that to speak thus is but a cloak for our ignorance—that an indwelling tendency to develope, a constructive force, or an ordained becoming of living things, is not a *vera causa*, or assimilable to known causes,[1] and that we must renounce such views, though, in our turn, we may be equally little satisfied with the reasoning which professes to explain the phenomena which we witness by chemico-mechanical and molecular considerations. There are, say the Evolutionists, certain aptitudes of this kind causing matter to evince life; such, for example, are the great contrasts in the primary elements of living tissues as regards molecular mobility, extremely great in those that are gaseous, and the reverse in carbon, and hence there arises in their compounds facility of rearrangement and of development; also there are contrasts as regards chemical activity, oxygen only having an excess of it, whilst the other elements are inert:—unlike units, in other words, are more easily segregated than such as are like. The secondary binary organic elements have less molecular mobility than the above gaseous ones, but more than the corresponding inorganic ones, and chemically speaking, are comparatively unstable, and commonly not very active, but water and carbonic acid are exceptional in some points, and the latter antithetical in relation to organisms—water difficult to decompose, but transformed into vapour at moderate temperatures; carbonic acid greedily seized by water, and constituting the main supply of nutriment to vegetables by its decomposition, whilst, on the contrary, in its formation animals get rid of

[1] Does the *unique* nature of the cause, if we may use such a term, prove that it is not a true cause?

their used-up or noxious materials. As the elements combine into more compound or tertiary proximate constituents their atomic units have greater weight, and consequently the compounds themselves have less mobility; they are mechanically fixed, but chemically unstable, though with no active tendencies: *isomerism* or *polymerism*, however, is often manifest in them, constituting a mode by which redistribution of matter and consequently the alteration of quality is shown; *allotropism* evincing the same effect in the simple elements, carbon, oxygen, phosphorus and sulphur. The most compound or quaternary constituents are non-mobile mechanically speaking, and chemically non-static; they are of high atomic complexity, without polarity, and hence non-crystallisable. The colloid form with its peculiar *energia* can be put on by these compound constituents; it gives plasticity and the power of transmitting fluids and the more active products of decomposition, even through membranes, by *dialysis*. The small atoms of the simpler elements are a requirement, or there could be no organic change; whilst the complex or large atomic units of the compound proximate principles are at the root of the fixity of the organic tissues. The nitrogen is an element of decomposition directly or by catalysis. The quaternary constituents are often only partially soluble in water, and are inert, except when colloid: their large atomic units are mechanically weak, and small forces may break them up; organic atoms are also susceptible of new arrangements from such agencies as the vibrations of heat, light, and electricity. Moreover, whatever deficiency the atoms or units may evince, as constituents of living plasm, is eked out by what is termed "physiological polarity," something not very different one might suppose from what others term vitality.[1] Osmosis and capillary attraction are modes too through which the environments may influence the organism.

The above is, we fear, but an imperfect analysis of the first chapter of the 'Principles of Biology' a work advocating evolution (*in toto*) in a most thoughtful manner, and it must be confessed, at least by me, difficult to controvert, however unsatisfactory it may be. No doubt the properties of organic matter,

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[1] "We must infer that a plant or animal, of any species, is made up of special units, in all of which there dwells the intrinsic aptitude to crystallise in a particular way." "In the one case as in the other" (the restoration of the lobster's exuviated claw, and the budding of a portion of the Begonia leaf) "the vitalised molecules composing the tissues, show their proclivity towards a particular arrangement; and whether such proclivity is exhibited in reproducing the entire form, or in completing it, when rendered imperfect, matters not." Spencer, 'Principles of Biology,' 1864. Such units or molecules do not seem to differ much from the "manufactured articles" of Sir J. Herschel or the vitalised "monads" of Leibnitz.

mechanical and chemical, are adapted to the origin, continuation, and action of life, but we are called upon to admit more, or rather, in one sense, to be content with less; we must look to the exterior and its incident forces, and to the organism, or rather to the chemico-physical properties of the constituents of which it is composed, and their respondent and equilibrating actions, and see in these the sum total of evolution and life, and this according to the known laws of physical and chemical force, with which, if we use the term vital force, it must be correlated, being but a modification say of heat, and into it very convertible, as both are into motion. Indeed, we grant that the effect of heat on organic bodies is great and intimate, as for instance, in the germination of seeds, the growth of plants, the development of the egg, and on the functions of the animal frame generally. As remarkable is the effect of oxygen or that of light on plants. But we must not confound collaterals with the cause. Vitality, though intimately connected with heat, shows a distinct and remarkable power of controlling and limiting it to a range of a very few degrees; neither can vitality be transferred to another individual, except by genesis of some kind, being, unlike heat, light, or electricity, non-diffusible, and even limitable by a fine membrane. The physicists too despair of correlating nerve-force with the others, and make but clumsy attempts to explain either it, or muscular contraction; attributing the former to the generation of a facile tract for impressions through the general cellular tissue, and the latter to the subtile and rapid chemical or isomeric action of the unstable muscle. There is, say the physicists, nothing inherent in organisms but an overruling exterior, and their response; nothing to subordinate the whole, unless it is the effect which the increase of one function necessarily brings about in others. Perhaps, however, it remains to be proved that vital function is not originated from within, and also that vital and physical manifestations strictly correspond.

We are required by those who may be termed physicists, in contradistinction to the vitalists, to receive and to rest satisfied with certain definitions of life, which may be said to apply more particularly to life in action or rather to the actions or functions of life—*the totality of functions which resist death—successive phenomena in organisms limited to a period—a continuous movement of composition and decomposition—a series of definite and successive changes in individuals.*[1] But the vitalists infer that life precedes organisation, as is seen in the Monera, in the impregnated egg, or vegetable embryo, and that it may be potential though dormant. It is an endowment by which matter of a suitable quality

[1] According to Mr. Spencer, *the continuous adjustments of internal relations to external ditto.* This seems adaptation rather than life.

attains and maintains individuality for a certain period, and is no longer amenable to the uncontrolled influence of physical or chemical force, but manifests phenomena of a totally different character.

But, further, when the above points are settled, one way or the other, to the satisfaction of our minds, we are brought face to face with other questions which may have still greater interest for us. Whence arise the mechanisms and adjustments which we see in organised beings, and which are by no one more admirably displayed than by the author of the 'Origin of Species'? We are now required to give up those teleological views of intelligent design which may have delighted our minds; and are scarcely allowed to adopt the view, that although all things are governed by unchangeable laws, yet such laws imply a primary intelligence, able, at least, in the language of the Reign of Law,[1] to modify one force by the operation of another. We are referred to an extraneous and mechanical cause, the direct action on molecular matter of the environment, as producing the appearance, and responsive growth, and the differentiation of plants and of animals. With this so-called *law of direct action* we have also one of *indirect action*, tantamount to natural selection, the *direct equilibration* of the organism with the exterior, and its increasing complexity as the exterior becomes varied constitute evolution. But the use of this term appears to be liable to many of the objections which are brought against the use of the term vital force, and indeed we are told that its inscrutable cause lies in the region of the unknowable. With respect to the direct and immediate effect of the exterior as taught by Dr. E. Darwin, Lamarck, and Mr. Spencer, we cannot attribute so great an influence to it *per se*. Can light generate the eye, or sound the ear, the last perhaps as wondrous as the first?

Natural selection is no doubt a true agent in the perpetuation of varieties in plants and animals, but it is not a theory of life, and it is powerless even in its own province without a tendency to vary; on what depends the tendency? Mr. Darwin does not undertake to explain the cause of it; the evolutionist derives it from ancestral proclivities, often of very remote origin. Here we are led to wonder that the *primum mobile* from whence springs that constantly increasing perfection which it is the problem to explain, should be derived from characteristics lower in the geneological tree, and consequently of a less advanced nature. Evolution, however, in addition, admits that there may be some change in organisms from

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[1] See 'Good Words,' Duke of Argyll, 1865.

functional development brought about in the system in direct response to the action of the exterior, and of necessity influencing the structure and functions of other parts *en liaison*, as alluded to above.

But to our minds side by side with the development, or as Owen terms it the derivation of animals, one from another, *purpose* seems evident; and in fact the study of such final cause, instead of repressing research, as it has been said to do, has often been the guide to anatomical discovery. If we are driven from this, some form of Pantheism seems only to remain for us, deifying the natural powers themselves, rather than adopting an exclusively materialistic or molecular doctrine of life. At any rate we rest in the hope that, whatever view we take of the nature of life, or the origin of species, be we vitalists, or physicists, or evolutionists, it does not follow that intelligence and design should be banished from the cosmos, and we surely are not forced to do what thoughtful heathen—Galen, Cicero, Seneca, and Plutarch—were zealous against. The argument derived from the evil, imperfection, and pain, existing in the world (the great mystery!) used against design, may become a dangerous one, and be carried to greater lengths than is desirable. Though early impressions are, we are told, of a very generally erroneous kind, yet it appears a very strong one, and almost bordering on the innate, that all that we see beautiful and adapted in nature is attributable to design and not to the fortuitous.[1]

Granting the truth, with the above *proviso*, of natural selection and of development from the simple to the differentiated—of the derivation of one from another—we may inquire whether species and genus have any real existence as such, or are they merely abstractions of the mind of the systematist? Is not the essence of species, in this case, the form rather than the object, and is its non-reality proved because that form may change to some other under certain circumstances? We presume that in forms avowedly liable in their nature to variation, yet, in the main, and in the majority of the individuals, constant, as far as

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[1] The wonderful and admirable correspondence of organizations with their surroundings and of organs to their functions is admitted by most, though some affect to consider it as sometimes imperfect, or bungling, or at any rate as the product of no highly qualified or beneficent workman, but a mere matter of course. We may ask such to point out better modes of accomplishing these adaptations and functions, or to tell us what would be their feelings were any fault or derangement of nerve, vessel, duct, or membrane to occur in their bodies. The *derivation* of these correspondences is what has been principally disputed. That they have grown up in *liaison* with the environment we are willing to grant; that they are from the mere sifting of congruities and incongruities we doubt; and still more that they proceed from the working of mere molecular force.

we can see, to certain characters, it is philosophical to consider the common type as a reality, and not the less if it should ever happen that the variations of a second type trenched upon and assimilated with those of the first. Looking back through geological time organic types certainly seem to have constantly appeared and disappeared on the earth, and, upon the whole, the simpler forms seem to have been succeeded by the more perfect, yet the geological record does not clearly and fully show a gradual transformation, apparently pointing out that either itself is very imperfect, or that advances of a more sudden character must have occurred from time to time, either from meteorological or geographical changes, in the *instance of generation*, or from some other unknown cause. In our present vista, species, though subject to variations, appear in a sense unchangeable, so far that to the prevalent forms from which they diverged the varieties have a strong propensity to return. Such a tendency is even seen in the common pigeon in all its vagaries from the rock dove, and, besides, the pigeon type seems indelible in these extreme variations. Without any pledge to a Platonic system of idealism, therefore, it may be allowable to believe that species in the animal kingdom are in one sense realities, or whence come the above permanence and reversion? There here appears a real difference between species and variety, and a difference which does not seem well accounted for; besides we have the equally generally true and well-known fact, that though two varieties may breed together normally, yet two different species, however near, very rarely produce fertile offspring. Species, too, continue for an immense time in spite of causes of disturbance, constituting stereotyped phases of development. The same species of Megalichthys, Palæoniscus, or Platysomus, seem to be found through a series of coal strata a mile in thickness, and the writer has sometimes been struck with the circumstance that on the same shore, or brought to shore, it may be in the same fishing boat, may be seen numbers of siphonostomatous molluscs, Buccinum, Fusus, and Voluta for instance, animals of distinct but closely allied form—of the same habits, one would suppose, and of the same geological age, yet, though liable to varieties and of wide distribution, they have continued to retain their typical character for vast ages as far as we can ascertain. Again, though most thoughtful minds have imported the doctrine of gradual development or progressive metamorphosis of some kind into biology and physiology, that is, as the law of action of a special power which is neither allied to the ordinary physical agents, nor the result of the whole series of them,—yet the apparently simultaneous origin of all placental mammalia with the Eocene is remarkable, and seems to point out some more rapid introduction of forms on the earth at this period than could be brought about by an uncontrolled evolution or natural selection. At this point the geological record must be imperfect indeed, for representatives of all the mammalian orders seem to appear at once—Balæna, Ursus, Equua, Sus, Cervus, Bos, Elephas, Phoca, Canis, Felis, &c. (Linn.); our present flora also being contemporaneous. The Cephalopods of the more ancient strata have conversely disappeared and left little trace behind of their wondrous forms, and so with the reptilian life of the Mesozoic. Sir W. Logan says, with respect to the Eozoon, "that the distance of time separating the Lower Laurentian, where the fossil occurs, from the Upper Cambrian may be as long as that separating the latter from the nummulitic limestone of the Tertiary; yet during this vast period Evolution apparently was reposing; Trilobites, Oldhamia, Lingula, Orthis, and worm-tracts constitute all the signs of life to be found. As far, therefore, as the, no doubt, imperfect record goes, Evolution would appear to have had its periods of inactivity as well as of activity.

Driven into rougher ground from our pleasant pastures of the belief in the sustention of living beings by an intelligence, or in their being subserved by an innate principle of life, in itself nearer to intelligence than any blind physical force,[1] we are of necessity led to examine, a little further, the doctrines of evolution, which profess to explain, as already observed, the first appearance of organic forms as the result of chemico-molecular force in highly unstable compounds, and the further modification of the same forms as caused by direct or indirect equilibration,—that is, the incidence of external and surrounding agents upon them, and their corresponding response. Evolution, its disciples say, can be inducted no higher; the formation of a primordial organism is but analogous to the formation of a crystal or a septarium; consequently, Evolution apparently implies a kind of heterogenesis.

It is the environment that causes one surface of an animal to show the dorsal characteristics, the other the abdominal or pedal. Progression of any kind entails that the anterior part becomes the head, the opposite the tail, and symmetry is of course largely dependent upon the capability of progression. The jointed form of the articulated animal is due to the process of division or budding, so common in the lower animals, different from the jointed disposition in the vertebrata, where it is merely adaptive, and brought about by simple mechanical means, just as we see, when we bend a stick of warm sealing-

[1] "A single power through the whole, and that a living one."

wax, a tendency to crack. *En passant* it may be observed that if this doctrine respecting the articulata be true it deducts from the difficulties of a serial arrangement of the animal kingdom. But the limitation and fixedness in the number of joints, and the peculiar character of definite sets in the chain, seem to show that the doctrine is incorrect. The difference in the claws of the hermit crab is said to be an instance of form being determined by external incidence; but this perhaps hardly explains the difference of form in those of the lobster, though the animal's voluntary elective use of them may do so. The other organs have an equally simple and mechanical origin; so the digestive organs, commencing with the involution of the endoderm within the ectoderm; so the lungs, an advance upon gills, brought about by what we may see in confined gold fish, or in the fish of a pond, whence the water is gradually drawn off; such fish rise to the surface and take in by the mouth a quantity of air, thus imitating lungs. Of course such views as the above are incompatible with the doctrine of the archetype vertebra.[1] The formation of vessels is explained upon mechanical principles, but that of the central organ, the heart, puzzles the evolutionists, and so do nerve and muscle, as already alluded to, their action due to the rapid changes which highly unstable matter, whether colloid or not, is capable of, though contrary to its usual rather slow changes, but now, perhaps, connected with some isomeric action.

The size of animals has generally been considered as specially adapted to the circumstances in which they live, not omitting from the consideration gravitation, strength of material, and such like; the evolutionists explain it more simply and mechanically with reference to the supply of spare nutriment, the force expended in other directions than in growth, and the size of the egg or fœtus.[2]

Evolutionists argue that many species are not especially adapted for their present habitats, or rather that other species might

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[1] It is now said, we believe, that traces of segmentation are found in the basal cartilage of the skull from the first. But much more than this segmentation is implied in the formation of the vertebral column.

[2] The egg of the cuckoo ought to be three or four times as large as it is, considering the size of the bird. Though a bird will sit on a stone, yet it must be somewhat like its own egg; and so the cuckoo's egg resembles that of the much smaller bird in whose nest it is commonly deposited. The bird sometimes oviposits in the nest of the hedge-accentor or the whin-chat, both of which have the eggs blue, like those of the American cuckoo which builds its own nest. There appears design here, but at the same time something like the derivation of species. Mr. Spencer says that actiniæ do not dwindle if not fed; this we think is an error with some species. Small perch (as well as the small male salmon) have sexual development, and Mr. S. discusses, and his discussions are full of interest, which is the natural state of the species, the small or the large size.

thrive better in such localities; for instance, English weeds have been introduced into New Zealand and flourish so well that they threaten to exterminate native vegetation, a reason, one should suppose, for their not having been planted there by nature. European animals threaten to displace the Marsupialia of Australia, but the first are protected by man, and it has also been shown, we think by Owen, that the latter are especially adapted for such a country, that is as feral animals, where at times food and water are only procurable at very distant spots to which the unaided young could not attain.[1]

In vegetable morphology many structural arrangements are ingeniously explained by evolution, but often on very mechanical principles. Some of them must have been evident to most observers, though they may not have looked upon them as *veræ causæ*, for instance, the formation and condensation of the woody axis in di- and monocotyledonous plants. As regards the latter—the stem of which is formed by the sheathing and closing leaves—the evolutionist would not sympathise, we suppose, with the old Italian philosopher who, as the story tells, when summoned before the Inquisition for heresy of a deep dye, took a straw which clung to his garment, and exclaimed that the consideration of the structure and function of that straw convinced him of the existence of a God. A straw is, indeed, like many other things in nature, an example of adaptation. No principle is said to be evinced in the morphology of the leaf-stalks of plants; they are commonly, however, more or less like the letter v in section, hollow or filled up, and such a form appears well adapted for strength, and to support the leaves in the horizontal position; no doubt the leaf-stalks have many modifications, such as the round one of a peltate leaf, the compressed ones of the aspen, or the winged and tubular supports of the Calathea.[2]

In all the above examples we may doubt whether the supposed agents are sufficient for what is attributed to them—whether evolution contains more of reality than the superseded vital force, or whether it be not the mode rather than the cause. Another factor seems wanting for the appearance of life upon the globe and for its maintenance;[3] at the same time credit must be

[1] That like organisms are not generally found in like habitats, appears to tell as much against evolution as against design.

[2] Why have the aspen, the white poplar, and the abele their tremulousness, and the two surfaces of the leaves strongly contrasted? Is it to attract the little Melasoma, which abounds on them, as well as Lepidoptera and other insects, or to give life to the dark and damp flats on which they grow?

[3] "You will get out of your atoms by 'evolution' exactly as much and no more as you have put into them by hypothesis. Science teaches the 'how' and theology the 'whence.'" "Modern Materialism," J. Martineau, 'Contemp. Rev.,' Feb., 1876.

given to the equilibration, or the mutual correspondence of organisms and the environment, to the survival of the fittest and the extinction of the unfit, as well as to development or derivation in the economy of nature. But admitting so much, we discard the theories of the aimless and fortuitous construction of animals, and demur to accept the theory that life is but a form of physical force, or to renounce the teleological doctrines of design, seeming in the last case to give up the *à posteriori* arguments for what we have considered as one of the first principles of belief. Where there is room for incertitude, however, it behoves us to admit that truth is more sacred than all:—

"Quid si ruat cœlum?"

It may be observed that Dr. S. Clarke, who has probably written on this point as well as any man, admits that it might be held that "infinite wisdom, foresight, and unerring design originally so ordered, disposed, and adapted all the springs and series of future necessary and unintelligent causes that, without the immediate interposition of Almighty Power upon every particular occasion, they should regularly, by virtue of that original disposition, have produced effects worthy to proceed from the direction and government of infinite wisdom."[1] So writes Dr. S. Clarke, and though he was suspected of minor heresies, he never was on these points.[2]

Confining ourselves to what we are most familiar with—rather humble creatures—we may give a few examples of what appears to us as something more than undesigned equilibrium of the organism and its exterior; but in this, as in other subjects, mistakes may be made, and it would not be fair for any such misapprehensions to affect the issue of the case; moreover, in the interpretation of facts there may be a quota of truth in different views.[3]

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1 'Discourse on the Being and Attributes of God,' 1749, p. 159.

2 "Irregularity of method is a mark of weakness, uniformity of method a mark of strength. Continued interposition to alter a prearranged set of actions implies defective arrangement in these actions. The maintenance of these actions, and the working out by them of the highest results, implies completeness of arrangement." 'Principles of Biology,' vol. i, p. 354. Mr. Martineau compares the uninterrupted reign of law in the universe with the automatic actions of intelligent beings, primarily originating in their will.

3 To affirm *purpose* in the adjustments of the world is not to set up a rival principle outside their producing force, but to plant, or rather to leave an integrating thought within it. And conversely, to trace these adjustments to their "physical causes" is not to withdraw them from their ideal origin, bnt only to detect the method of carrying the inner meaning to its realisation. Who will venture to say, what nevertheless is constantly imagined, that to find how a change comes about is to prove that it was never contemplated? If it were contemplated, it would have to be executed somehow. J. Martineau, 'Contemp. Rev.,' March, 1876.

There is, perhaps, as little in the Mollusca as in any class of animals of the mechanical and symmetrical, and yet enough, we think, to claim our notice; and, first, we will ask how is their protection provided for, and especially that of the branchiæ? for the action of oxygen on these branchiæ is of tantamount importance with nutrition, nay, more so, for its want is more immediately felt; it is only by respiration that the gross product of nutrition is, by a kind of reverse process, freed from elements which are not assimilable, or worse, noxious, and at the same time refined to a net product, fit to sustain life, and especially the nervous and muscular systems. Here we must bear in mind that it is only their habitual and normal protection that is provided for; many of them being required for the food of man, of birds, of fishes, and of other molluscs, are destined to subserve the general good. There is no more massive shell on our coast than Venus Islandicus, with its closure strongly secured, yet the sea-cat (Anarrhichas) is able to crush the valves with its powerful teeth, and discharges the pieces afterwards, very imperfectly comminuted and liable to be mistaken for the similar fragments found in the drift. So, probably, the strong but beautiful Trigonia is amenable to the powerful jaws of the Port Jackson shark; the representatives of both shell and fish also existing in the oolitic age. Ordinarily, safety and protection are well secured in molluscs by their shell coverings, which in bivalves open by means of an elastic substance, variously disposed at the hinge; yet are they quickly closed if need be by internal muscles; the soft-bodied tenant being also often guarded by argus-like eyes disposed along the slit and shining like emeralds,—probably light, but not object, organs, and giving warning for closure to the strong janitor muscle when any shadow falls upon them. Such is the disposition in the pecten or scallop, where, moreover, as commonly the most concave valve lies undermost, the consequence is the animal settles down on it in the water. The smaller species of scallop, with more equally hollowed valves, have very active movements caused by the contraction of the adductor muscle above mentioned, and the sudden closure of the valves. A few placed in a pail of fresh water soon leap out. The security of this and numerous other shells is increased by the ribs and ridges of the valves locking into each other, but primarily this security is ensured by the hinge itself, much varied and very strong, and its processes or teeth admirably fitting into each other, often like a butt hinge, as in the spondyle shell or clamp. The ligamento-cartilage or elastic substance opening the valves is remarkably varied in different species and for different ends.

In pecten it is internal, and simply acts like a piece of compressed caoutchouc, opening the valves widely by regaining its natural state, which here may be done safely from the short dorsal junction of the mantle. In the thin and brittle Anatina it rests between two spoonlike processes, buttressed with ridges, the only way of obtaining a firm foundation on the fragile shell; and so disposed, its action is more limited than in the former case, neither allowing the shelly valves to constrict the large respiratory siphons by closing too much, nor to tear the united sacciform mantle by a too great divergence. In other species the so-called cartilage may be half internal, half external, and act both by tensile and resilient elasticity.

In the common Anodon, or the Iridina, it is such a hinge as would be formed by doubling up a piece of strong leather. The teeth adjunctory to this hinge vary infinitely; in the oyster they are obsolete, for the adductor muscle is strong enough to guard the animal from everything but the oyster-knife. They are large and beautifully fitted into each other in Trigonia, though often deficient in other cases where there is the same interlocking of the ridges of the valves, or if the shell is small, flat, and polished, and so exposed to little violence. Arca has a long straight hinge, with rather weak ligamento-cartilage, but the teeth are very numerous and saw-like; and the umbones of the valves far apart, to allow of their wide opening and of the protrusion of the massive foot. This arrangement necessitates the division of the heart into two ventricles. Beautiful as the teeth are in Trigonia or Nucula, they are formed by a simple interposed portion of the membranous mantle, more glandular where the cartilage has to be secreted. That the scallop is an inhabitant of deeper water than the oyster or mussel is shown by the open spaces or imperfect closures near the ears of the shell, through which in some species a byssus makes its exit, mooring to the rocks the otherwise detached animal. An incomplete closure would be fatal to an animal liable to be exposed to the air from the concentration of the sea-water. When it attains the saltness of thirty grains of salt to the ounce it becomes a poison, whilst the action of fresh water is the same; the naked Doris crawling on the rocks has the power at ebb of tide of retracting its delicate ciliated branchiæ from the sun or rain, or with other naked-gilled molluscs will lurk under the wet algæ. The limpet, in hot days, sticks firmly to the rocks so as to prevent the drying of the confined moisture. Those bivalves which, like the common mussel, are exposed on the bare shore to the action of the sun and rain, have the valves fitted to each other most exactly, preventing all evaporation; other species burrow at the retreat of the tide into the sands, and so obtain protection for their ciliated structures.[1]

Shells, though often so beautiful, are but dead exuvia, and consequently the growth of the contained animal can only be provided for by fresh laminæ successively enlarging, and secreted between the fleshy matter and the old layers. From the growth of the animal it follows that all shells have a minute nucleus to start from, and are wonderfully varied in form as growth proceeds. Univalves have essentially conical shells, covering the branchiæ and viscera of the animal, and taking on the spiral or volute form as they increase, and this on the same plane or not, producing the very pleasing and infinitely varied form of these shells. Coloured as they often are in a beautiful manner, we cannot but suppose that there is here variety and beauty introduced for their own sake; in fact, there appears very little beauty in the world but what is immediately or mediately connected with organic objects. It is pretty evident, at any rate, that sexual selection can here have no hand in the matter.

It is the circumstance of the many modifications which the shells of molluscs are capable of that excites interest—*modification* rather than *development*—in one direction. We see the ordinary bivalves covered by their shelly plates, as a book is by its binding, now secured at the back as a book is, now strengthened in front by projections and corresponding sinuosities, and very varied in their general form;—fan-shaped and pointed below in the Pinna, by which means the animal lodges itself in the sea-bottom, further securing itself there by its beautiful byssus, whilst the common mussel, a somewhat allied mollusc, becomes firmly packed into the tessellated bosses which we see on the rocks;—acting as splints for the long bodies of the razor-shells which burrow deep in the sands by means of their very effective foot;—modified into an augur in the ship-worm and disintegrated so as to form besides a long cylindrical dwelling, the palettes acting as a door. In some, one valve may preponderate and form a sessile and firmly fixed cup, whilst the other becomes a well-adapted lid, as in many fossil forms called Rudista, and certainly some of these seem almost rude and rough enough to be the product of some obscure physical force. In the Brachiopoda or lamp-shells the valves are curiously transposed, or, at any rate, arranged in the opposite plane to those of other bivalves, and the lower valve is often attached by its elongated beak to the rocks, and in this case also the other valve forms a cover, whilst within is a very curious

[1] 'Mag. of Nat. Hist.,' 1838.

mechanism, too varied and complicated for us to attempt to describe. Then, again, the coalesced shells of the bivalve form the conical dwelling of the limpet, or that of Dentalium, shaped like a perforated elephant's tusk, and through such forms as the ear-shell or Haliotis, Emarginula, Calyptræa, Dolabella, &c., the spiral form is attained; and, finally, one side becomes atrophied, and consequently one valve absent, except as the curious operculum, still, however, useful to close the mouth of the spiral cavity.[1] Some shells are beautifully light for natation or floating, others heavy and spiny for rocky shores. The remarkable shells of the extinct Cephalopoda, probably in many instances, rendered buoyant the animals which formed them by their hydrostatic cellular structure.

Growth in shells can only take place in the way mentioned, by the deposit of new layers, and the shell itself being extra-systemic can afterwards be but little modified, though it is so to some extent by similar modes to those by which rocks, &c., are worn away by these animals; a tubular shell may lengthen but cannot expand, though the shelly coverings of some cirripedes are capable of disintegration in certain lines and so may enlarge their cavities laterally. All this, no doubt, can be made assimilable to evolution, but we see no ground to suppose that the influences of the environment are the sole factors.

If security be accomplished in such shelly domiciles, how is locomotion performed in such molluscs as have it? for some are absolutely fixed to the rocks and to other bodies in various ways, of which we need only mention that by a byssus, the strong horny threads seen when we open a common mussel. These threads are formed from the secretion of a particular gland situated behind the front muscular attachment of the foot, and into the groove of this tongue-like organ the gland pours its secretion, where it is moulded, and afterwards attached to the tendinous point at its base. This foot is very extensible as well as capable of casting or moulding the secretion in its groove, and hence of attaching the threads to the rocks, or to other mussels by little disks, matting all together in a firm mass. Very frequently this organ is even further developed, and in the bivalves it is attached by strong retractor muscles to the interior of the valves, comporting itself like a tongue, or foot, or finger, or proboscis. The movements of molluscs are, creeping in various ways as well seen in a common snail, swimming in the higher genera, but for this special organs are developed, and burrowing or boring. Though the last is perhaps *par excellence* the faculty

[1] This, however, is a disputed point of homology.

of the foot, yet it may also act as a spring, a crook, a boat, a clasp, an anchor, or even as a spoon; whilst the divided or differentiated foot or so-called arms of the cuttle-fish, with their curious acetabula or suckers, act as deadly grappling irons, though with a somewhat different mechanism in different species.

When this foot is not developed as in the Ascidiæ, the Brachiopoda, or in the oyster, the animal is indebted solely to its vibratile cilia, so common in the lower animals, and here covering especially the branchiæ and interior of the mantle, for the inbibition into that mantle, or pallial-chamber, of rapid streams of water, which not only convey from a distance the nutritive organic particles floating in the vicinity, but also aërate the branchiæ. Very beautiful is the action of these cilia when seen under the microscope, as beautiful and wonderful as the circulation; and very varied is the hydraulic mechanism of the mantle in the bivalves to direct the flow of the stream when it is drawn in or forced out; in fact, so varied that it is not difficult to classify them from these arrangements alone.

In the foot of bivalves is a peculiar body called the crystalline stilette, respecting the homology of which perhaps something might be said, but of which a simple use is to act as an internal support, giving resilience to the foot in its various movements, and helping to restore it to form after retraction; it appears to confirm this view that it is very long in the Anomia, and here is lodged in a promontory of the mantle, which in this animal is free and with little to keep it in position.

We have alluded to the modified foot or prehensile arms of the Cephalopoda. Here the organs of locomotion and of respiration are connected together, and undergo several modifications in different species. On the wet rocks the Octopus uses its long arms for progression—climbing or walking, carrying its flask-shaped body above; but swimming also is accomplished by the expansion and closure of the circle of arms in unison, this being made more efficacious by their being more or less webbed at the centre; here progression is by starts, the arms trailing behind. In the Sepia the water is taken in by the wide fissure seen between the head and the body, produced by the detachment of the fleshy mantle or envelope of the body; the mantle expands like a common india-rubber bottle in order to draw in the sea water. When the water has served its purpose the mantle contracts, and two large folds or valves at the base of the neck now rise and prevent the water from leaving by the same fissure, but allowing it to escape through a fleshy siphon or funnel, having itself a valve in the interior to prevent the entrance of the water that way. Through the funnel the ink and *rejecta* also pass out, and to keep the funnel, valves, and mantle in position during these acts there is an extremely curious mechanical contrivance; there is on each side a ball-and-socket joint formed in the base of the funnel and on the mantle, but capable of temporary dislocation.[1] These respiratory movements drive the animal backwards, but it is not solely dependent on the above provision for locomotion, for it has, in addition, two lengthened fins at the sides of the body, by means of which it can move itself in any direction in a very beautiful manner, often the head first and the back upwards; this last position being secured by the lodgment in it of that light spongy hydrostatic body called the cuttle-fish bone, no bone at all (though the animal has such, having a resemblance to the internal skeleton of the skate), but the homologue of the hydrostatic cell system in the Nautilus, and of many extinct and curious allied shells. The Loligo is also well organised for locomotion, shaped like an arrow for progression, and also capable of springing out of the water; whence the sailor's name for it, the *flying squid.* Their ink is also another means by which the Cephalopoda evade their pursuers, as they can, by discharging it, discolour a large quantity of water. The analogy of the longer or tentacular arms of the Onychoteuthis with certain surgical forceps, constructed with an *extempore* joint, has been pointed out—the grasping parts at the ends are armed with hooks, but lower down they are capable of being locked together by means of unarmed suckers or cups; many Cephalopoda have two very long supernumerary arms by means of which they can anchor or tether themselves, at the same time allowing a pretty wide exploring ground.

Many are the modifications, as already observed, which the molluscous type is capable of; not the least remarkable being that of the borers into the hard rock, taking the external form, to an ordinary eye, of a worm or an annelid, but their own type in all respects remaining: the Aspergillum is very curiously changed, yet it has still the characters of a bivalve mollusc. How the boring of hard rock or wood is accomplished is matter of dispute; nature has more ways than one of performing its task. In some cases there is, no doubt, mechanical work done by means of the valves, in other cases this cannot be; in some there is attrition by the fleshy foot, aided perhaps by gritty particles; in the ship-worm (Xylophaga) and wood-pholas there is a pore in the centre of the foot to which the crystalline style is directed, and the pore may give exit to a

[1] The branchiæ of the Cephalopoda are not ciliated, 'Trans. Linn.,' 1834.

solvent fluid from the stomach, so aiding the mechanical action of the valves—at least of those of the ship-worm. But in all these operations the strong currents, produced by ciliary action and directed downwards, and the never-ceasing effect of the applied ciliated foot, are probably prime factors—

"Dura tamen molle saxa cavantur aquâ."

Unlike the earth-dwelling molluscs, the little light Pteropoda swim through the clear ocean, in much the same way as butterflies sail in mid-air, but here the above-named mantle is modified into two fins or wings,[1] whilst the foot is undeveloped, the wings exhibiting as beautiful tints as those of the insect. Sometimes a shell exists in these, and, of course, it should be light, which it is, and often beautiful; sometimes boat-shaped as in Argonaut, evidently organised for surface or mid-ocean, though the animal can also creep on the rock. Great is the beauty of structure and adaptation to its shell in this creature; though for long it was debated whether the animal found in the shell is the constructor or not. We can well believe that this little creature is really alluded to in the grand song of praise:

"There go the Argonauts, and there is that Leviathan whom Thou hast made to play therein."

Omitting other interesting points, the minute and extremely varied lingual apparatus of the higher molluscs; the branchial appendages of the nudibranchs; the heart and vessels, the latter more complete than has been thought; the digestive organs, with the extraordinary armature of the stomach, and the beak of the cuttlefish, we will pass on to instance a very few points from the Articulata.

Réaumur's volumes constitute a mine of information respecting the wonderful habits and structure of insects. We shall only supplement them with one or two observations on points of structure, where we are disposed to believe that prospective adaptation is manifest, and that in Crustaceans, not perhaps the most curiously organised of their class. *En passant* we may observe that the metamorphosis of insects appears to us to instance that change of development which all organisms in a greater or less degree avowedly undergo, and to prove its existence; it is too an instance of a kind of origin of species and that before our eyes, but this not brought about by the action of environment, though in relation with it, aerial, aquatic, &c., but regulated from a *force from within.* We must also have, in this case,

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[1] But formed by the sides of the foot according to others, or its epipodia.

faculty or force inherited, rather than the peculiar molecules of the panspermists; unless we can suppose the egg to contain at once the germs of the grub, the chrysalis, and the imago; and these molecules to have a wonderful elective power of segregation, and as wonderful an aptitude to abide their respective time.

Leaving, then, the world of insects, their countless numbers of species, their exquisite but microscopic structure, the adaptations of their structures to use, their habits as regards their own preservation and that of their offspring, the relation of life of one species to that of some other or to some particular plant, their consentaneous faculties, and the formation of their habitations, we take a glance at another order, the Cirripedes, which Articulata may be arranged with or next to the Crustacea, and being a tribe of animals which the author of the 'Origin of Species' has almost made his own by his researches; we may give as our instance the eye of the Lepas. In the free swimming larvæ there are, at one stage, two eyes, but in the perfect animal, fixed by its pedicle, and with its body inclosed in an opaque mantle, and between shelly valves except at the chink in front, there is but one, situated, however, immediately behind the chink, and evidently sensitive to the light, like the mole's eye simply a light—and not an object—organ; it may be seen that the animal closes its valves upon every shadow passing over. Now, this eye lies deep in the body upon the stomach, and some have supposed that there is no possibility of the rays of light affecting it. This, however, is not the case, for a scrutiny will lead us to observe the little fact that in the loose external dark-coloured tissue, enveloping the animal's body, there is just at the point before the eye-speck a clear lozenge-shaped space, through which it is seen, and through which light can easily penetrate.

The moulting or eclysis of Crustacea is a necessary provision for the increase or growth of the animal. Without entering into the full history of this wonderful operation, that is, how it is effected in all respects, it may be mentioned that though Réaumur says that there is a splitting of the shelly covering of the large claws in the lobster, crab, and river cray-fish, to enable the voluminous soft parts to be withdrawn through the narrow base of the limb, yet generally this has been denied. But it is a fact that a splitting of the shell, at the narrow part, through the second and a portion of the first joint from the body, does take place, though in the exuvial shell this is not readily seen, as its elasticity restores it to form after it is cast off; but a minute examination will prove the fact; and, what is curious is, that in all crustaceans with these large fore-feet there is a *pro-*

vision for the moulting, a line of attenuated shell of a particular pattern, along which the shell always does yield, never giving way in any other line than in this. In the crab the body-shell is exuviated at the line marked on the sides.

The casting off of the limbs of these animals, when injured or trapped, or as it is said when frightened, is also noteworthy; and appears to us to be equally provided for, so as to be accomplished with safety. The separation does not take place at the joints, where the members of the limb meet, for in that case the tendons, being attached just above the junctions, must be forcibly torn from the interior of the muscles below, inflicting much injury, and probably death; but it takes place at a marked line at the narrow part of the limb (in the crab or lobster), at which line no tendons can be drawn out, for they are inserted just below the line of separation; neither is there any laceration of muscle, for none exists at this point, but only a formative plasm, (as was pointed out by Dr. Goodsir,) ready to commence of itself the formation of a new limb, and through which pass the nerve and vessel of supply. The muscular power exerted to cast off a limb must be great. In the separation a *point d'appui* is formed, by the opposition with the first joint of the process which projects backwards from that part of the second joint, which is beyond its contracted portion and the line of separation: then the intervening narrow part is acted upon with a leverage by the muscles inserted in its interior, but arising below in the body of the animal, this part which is retained being hinged as it were upon two opposite points of the joint below. The line of fracture is also marked within as well as without; and when examined, this fracture presents a different structure from what a fracture elsewhere does, for it has a transversely fibrous appearance, and a thin film of soft tissue extends from surface to surface.

It may be noticed that there is a difference in the fore limbs or mandibles of the lobster: one, which may be the right or the left, has a cutting edge with pointed teeth to the pincers, and is used for various purposes in feeding, &c., whilst the other is shaped like a pair of grapnels with blunt tubercles, and is fitter for the animal to anchor itself by, or to crush shells, or other bulky or specially hard food.

In conclusion we may give the following brief summary, omitting a few minor points, of the preceding remarks. First, we have recurred to the doctrine of the vitalists—of such men as John Hunter and Sir Charles Bell, not to mention other more precise thinkers—a doctrine denying that vital force can be reduced to any form of the chemical or magnetic, much less of those other forces, such as heat or electricity, which circulate in so unconfined a manner through the cosmos; but affirming that it is, as far as we can see or define, a more limited *energia*, indwelling, yet ever expanding, and oftener in opposition—rather than subjection to ordinary physical force. Secondly, we have endeavoured to show that the vital force, though autonomic in the above sense, is subservient—and, perhaps it may be said, more intimately related to a higher intelligence in nature; and to this, though pre-ordained law is ever adhered to, we would attribute the wonders of organic structure, as well as that beauty and adaptation in natural objects which all men, whatever their mental tone, do not fail to admire.