SPENCER HERBERT

ESSAYS: SCIENTIFIC, POLITICAL, AND SPECULATIVE, VOLUME I

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Содержание

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PREFACE

Excepting those which have appeared as articles in periodicals during the last eight years, the essays here gathered together were originally re-published in separate volumes at long intervals. The first volume appeared in December 1857; the second in November 1863; and the third in February 1874. By the time the original editions of the first two had been sold, American reprints, differently entitled and having the essays differently arranged, had been produced; and, for economy's sake, I have since contented myself with importing successive supplies printed from the American stereotype plates. Of the third volume, however, supplies have, as they were required, been printed over here, from plates partly American and partly English. The completion of this final edition of course puts an end to this make-shift arrangement.

The essays above referred to as having been written since 1882, are now incorporated with those previously re-published. There are seven of them; namely – "Morals and Moral

Sentiments," "The Factors of Organic Evolution," "Professor Green's Explanations," "The Ethics of Kant," "Absolute Political Ethics," "From Freedom to Bondage," and "The Americans." As well as these large additions there are small additions, in the shape of postscripts to various essays – one to "The Constitution of the Sun," one to "The Philosophy of Style," one to "Railway Morals," one to "Prison Ethics," and one to "The Origin and Function of Music: " which last is about equal in length to the original essay. Changes have been made in many of the essays: in some cases by omitting passages and in other cases by including new ones. Especially the essay on "The Nebular Hypothesis" may be named as one which, though unchanged in essentials, has been much altered by additions and subtractions, and by bringing its statements up to date; so that it has been in large measure re-cast. Beyond these respects in which this final edition differs from preceding editions, it differs in having undergone a verification of its references and quotations, as well as a second verbal revision.

Naturally the fusion of three separate series of essays into one series, has made needful a general re-arrangement. Whether to follow the order of time or the order of subjects was a question which presented itself; and, as neither alternative promised satisfactory results, I eventually decided to compromise – to follow partly the one order and partly the other. The first volume is made up of essays in which the idea of evolution, general or special, is dominant. In the second volume essays dealing with philosophical questions, with abstract and concrete science, and with aesthetics, are brought together; but though all of them are tacitly evolutionary, their evolutionism is an incidental rather than a necessary trait. The ethical, political, and social essays composing the third volume, though mostly written from the evolution point of view, have for their more immediate purposes the enunciation of doctrines which are directly practical in their bearings. Meanwhile, within each volume the essays are arranged in order of time: not indeed strictly, but so far as consists with the requirements of sub-classing.

Beyond the essays included in these three volumes, there remain several which I have not thought it well to include – in some cases because of their personal character, in other cases because of their relative unimportance, and in yet other cases because they would scarcely be understood in the absence of the arguments to which they are replies. But for the convenience of any who may wish to find them, I append their titles and places of publication. These are as follows: – "Retrogressive Religion," in *The Nineteenth Century* for July 1884; "Last Words about Agnosticism and the Religion of Humanity," in *The Nineteenth Century* for November 1884; a note to Prof. Cairns' Critique on the *Study of Sociology*, in *The Fortnightly Review*, for February 1875; "A Short Rejoinder" [to Mr. J. F. McLennan], *Fortnightly Review*, June 1877; "Prof. Goldwin Smith as a Critic," *Contemporary Review*, March 1882; "A Rejoinder to M. de Laveleye," *Contemporary Review*, April 1885.

London, *December, 1890*.

THE DEVELOPMENT HYPOTHESIS

[*Originally published in* The Leader, *for March 20,* 1852. *Brief though it is, I place this essay before the rest, partly because with the exception of a similarly-brief essay on "Use and Beauty", it came first in order of time, but chiefly because it came first in order of thought, and struck the keynote of all that was to follow.*]

In a debate upon the development hypothesis, lately narrated to me by a friend, one of the disputants was described as arguing that as, in all our experience, we know no such phenomenon as transmutation of species, it is unphilosophical to assume that transmutation of species ever takes place. Had I been present I think that, passing over his assertion, which is open to criticism, I should have replied that, as in all our experience we have never known a species *created*, it was, by his own showing, unphilosophical to assume that any species ever had been created.

Those who cavalierly reject the Theory of Evolution as not being adequately supported by facts, seem to forget that their own theory is supported by no facts at all. Like the majority of men who are born to a given belief, they demand the most rigorous proof of any adverse belief, but assume that their own needs none. Here we find, scattered over the globe, vegetable and animal organisms numbering, of the one kind (according to Humboldt), some 320,000 species, and of the other, some 2,000,000 species (see Carpenter); and if to these we add the numbers of animal and vegetable species which have become extinct, we may safely estimate the number of species that have existed, and are existing, on the Earth, at not less than *ten millions*. Well, which is the most rational theory about these ten millions of species? Is it most likely that there have been ten millions of special creations? or is it most likely that, by continual modifications due to change of circumstances, ten millions of varieties have been produced, as varieties are being produced still?

Doubtless many will reply that they can more easily conceive ten millions of special creations to have taken place, than they can conceive that ten millions of varieties have arisen by successive modifications. All such, however, will find, on inquiry, that they are under an illusion. This is one of the many cases in which men do not really believe, but rather *believe they believe*. It is not that they can truly conceive ten millions of special creations to have taken place, but that they *think they can do so*. Careful introspection will show them that they have never yet realized to themselves the creation of even *one* species. If they have formed a definite conception of the process, let them tell us how a new species is constructed, and how it makes its appearance. Is it thrown down from the clouds? or must we hold to the notion that it struggles up out of the ground? Do its limbs and viscera rush together from all the points of the compass? or must we receive the old Hebrew idea, that God takes clay and moulds a new creature? If they say that a new creature is produced in none of these modes, which are too absurd to be believed, then they are required to describe the mode in which a new creature *may* be produced – a mode which does *not* seem absurd; and such a mode they will find that they neither have conceived nor can conceive.

Should the believers in special creations consider it unfair thus to call upon them to describe how special creations take place, I reply that this is far less than they demand from the supporters of the Development Hypothesis. They are merely asked to point out a *conceivable* mode. On the other hand, they ask, not simply for a *conceivable* mode, but for the *actual* mode. They do not say – Show us how this *may* take place; but they say – Show us how this *does* take place. So far from its being unreasonable to put the above question, it would be reasonable to ask not only for a *possible* mode of special creation, but for an *ascertained* mode; seeing that this is no greater a demand than they make upon their opponents.

And here we may perceive how much more defensible the new doctrine is than the old one. Even could the supporters of the Development Hypothesis merely show that the origination of species by the process of modification is conceivable, they would be in a better position than their opponents. But they can do much more than this. They can show that the process of modification has effected, and is effecting, decided changes in all organisms subject to modifying influences. Though, from the impossibility of getting at a sufficiency of facts, they are unable to trace the many phases through which any existing species has passed in arriving at its present form, or to identify the influences which caused the successive modifications; yet, they can show that any existing species – animal or vegetable – when placed under conditions different from its previous ones, *immediately begins to undergo certain changes fitting it for the new conditions*. They can show that in successive generations these changes continue; until, ultimately, the new conditions become the natural ones. They can show that in cultivated plants, in domesticated animals, and in the several races of men, such alterations have taken place. They can show that the degrees of difference so produced are often, as in dogs, greater than those on which distinctions of species are in other cases founded. They can show that it is a matter of dispute whether some of these modified forms are varieties or separate species. They can show, too, that the changes daily taking place in ourselves – the facility that attends long practice, and the loss of aptitude that begins when practice ceases – the strengthening of passions habitually gratified, and the weakening of those habitually curbed – the development of every faculty, bodily, moral, or intellectual, according to the use made of it – are all explicable on this same principle. And thus they can show that throughout all organic nature there *is* at work a modifying influence of the kind they assign as the cause of these specific differences: an influence which, though slow in its action, does, in time, if the circumstances demand it, produce marked changes – an influence which, to all appearance, would produce in the millions of years, and under the great varieties of condition which geological records imply, any amount of change.

Which, then, is the most rational hypothesis? – that of special creations which has neither a fact to support it nor is even definitely conceivable; or that of modification, which is not only definitely conceivable, but is countenanced by the habitudes of every existing organism?

That by any series of changes a protozoon should ever become a mammal, seems to those who are not familiar with zoology, and who have not seen how clear becomes the relationship between the simplest and the most complex forms when intermediate forms are examined, a very grotesque notion. Habitually looking at things rather in their statical aspect than in their dynamical aspect, they never realize the fact that, by small increments of modification, any amount of modification may in time be generated. That surprise which they feel on finding one whom they last saw as a boy, grown into a man, becomes incredulity when the degree of change is greater. Nevertheless, abundant instances are at hand of the mode in which we may pass to the most diverse forms by insensible gradations. Arguing the matter some time since with a learned professor, I illustrated my position thus: – You admit that there is no apparent relationship between a circle and an hyperbola. The one is a finite curve; the other is an infinite one. All parts of the one are alike; of the other no parts are alike [save parts on its opposite sides]. The one incloses a space; the other will not inclose a space though produced for ever. Yet opposite as are these curves in all their properties, they may be connected together by a series of intermediate curves, no one of which differs from the adjacent ones in any appreciable degree. Thus, if a cone be cut by a plane at right angles to its axis we get a circle. If, instead of being perfectly at right angles, the plane subtends with the axis an angle of 89° 59′, we have an ellipse which no human eye, even when aided by an accurate pair of compasses, can distinguish from a circle. Decreasing the angle minute by minute, the ellipse becomes first perceptibly eccentric, then manifestly so, and by and by acquires so immensely elongated a form, as to bear no recognizable resemblance to a circle. By continuing this process, the ellipse passes insensibly into a parabola; and, ultimately, by still further diminishing the angle, into an hyperbola. Now here we have four different species of curve – circle, ellipse, parabola, and hyperbola – each having its peculiar properties and its separate equation, and the first and last of which are quite opposite in nature, connected together as members of one series, all producible by a single process of insensible modification.

But the blindness of those who think it absurd to suppose that complex organic forms may have arisen by successive modifications out of simple ones, becomes astonishing when we remember that complex organic forms are daily being thus produced. A tree differs from a seed immeasurably in every respect – in bulk, in structure, in colour, in form, in chemical composition: differs so greatly that no visible resemblance of any kind can be pointed out between them. Yet is the one changed in the course of a few years into the other: changed so gradually, that at no moment can it be said – Now the seed ceases to be, and the tree exists. What can be more widely contrasted than a newly-born child and the small, semi-transparent spherule constituting the human ovum? The infant is so complex in structure that a cyclopædia is needed to describe its constituent parts. The germinal vesicle is so simple that it may be defined in a line. Nevertheless a few months suffice to develop the one out of the other; and that, too, by a series of modifications so small, that were the embryo examined at successive minutes, even a microscope would with difficulty disclose any sensible changes. That the uneducated and the ill-educated should think the hypothesis that all races of beings, man inclusive, may in process of time have been evolved from the simplest monad, a ludicrous one, is not to be wondered at. But for the physiologist, who knows that every individual being *is* so evolved – who knows, further, that in their earliest condition the germs of all plants and animals whatever are so similar, "that there is no appreciable distinction amongst them, which would enable it to be determined whether a particular molecule is the germ of a

Conferva or of an Oak, of a Zoophyte or of a Man;"[1]– for him to make a difficulty of the matter is inexcusable. Surely if a single cell may, when subjected to certain influences, become a man in the space of twenty years; there is nothing absurd in the hypothesis that under certain other influences, a cell may, in the course of millions of years, give origin to the human race.

We have, indeed, in the part taken by many scientific men in this controversy of "Law *versus* Miracle," a good illustration of the tenacious vitality of superstitions. Ask one of our leading geologists or physiologists whether he believes in the Mosaic account of the creation, and he will take the question as next to an insult. Either he rejects the narrative entirely, or understands it in some vague nonnatural sense. Yet one part of it he unconsciously adopts; and that, too, literally. For whence has he got this notion of "special creations," which he thinks so reasonable, and fights for so vigorously? Evidently he can trace it back to no other source than this myth which he repudiates. He has not a single fact in nature to cite in proof of it; nor is he prepared with any chain of reasoning by which it may be established. Catechize him, and he will be forced to confess that the notion was put into his mind in childhood as part of a story which he now thinks absurd. And why, after rejecting all the rest of the story, he should strenuously defend this last remnant of it, as though he had received it on valid authority, he would be puzzled to say.

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[1] Carpenter, *Principles of Comparative Physiology*, p. 474.

PROGRESS: ITS LAW AND CAUSE

[*First published in* The Westminster Review *for April,* 1857. *Though the ideas and illustrations contained in this essay were eventually incorporated in* First Principles, *yet I think it well here to reproduce it as exhibiting the form under which the General Doctrine of Evolution made its first appearance.*]

The current conception of progress is shifting and indefinite. Sometimes it comprehends little more than simple growth – as of a nation in the number of its members and the extent of territory over which it spreads. Sometimes it has reference to quantity of material products – as when the advance of agriculture and manufactures is the topic. Sometimes the superior quality of these products is contemplated; and sometimes the new or improved appliances by which they are produced. When, again, we speak of moral or intellectual progress, we refer to states of the individual or people exhibiting it; while, when the progress of Science, or Art, is commented upon, we have in view certain abstract results of human thought and action. Not only, however, is the current conception of progress more or less vague, but it is in great measure erroneous. It takes in not so much the reality of progress as its accompaniments – not so much the substance as the shadow. That progress in intelligence seen during the growth of the child into the man, or the savage into the philosopher, is commonly regarded as consisting in the greater number of facts known and laws understood; whereas the actual progress consists in those internal modifications of which this larger knowledge is the expression. Social progress is supposed to consist in the making of a greater quantity and variety of the articles required for satisfying men's wants; in the increasing security of person and property; in widening freedom of action; whereas, rightly understood, social progress consists in those changes of structure in the social organism which have entailed these consequences. The current conception is a teleological one. The phenomena are contemplated solely as bearing on human happiness. Only those changes are held to constitute progress which directly or indirectly tend to heighten human happiness; and they are thought to constitute progress simply *because* they tend to heighten human happiness. But rightly to understand progress, we must learn the nature of these changes, considered apart from our interests. Ceasing, for example, to regard the successive geological modifications that have taken place in the Earth, as modifications that have gradually fitted it for the habitation of Man, and as *therefore* constituting geological progress, we must ascertain the character common to these modifications – the law to which they all conform. And similarly in every other case. Leaving out of sight concomitants and beneficial consequences, let us ask what progress is in itself.

In respect to that progress which individual organisms display in the course of their evolution, this question has been answered by the Germans. The investigations of Wolff, Goethe, and von Baer, have established the truth that the series of changes gone through during the development of a seed into a tree, or an ovum into an animal, constitute an advance from homogeneity of structure to heterogeneity of structure. In its primary stage, every germ consists of a substance that is uniform throughout, both in texture and chemical composition. The first step is the appearance of a difference between two parts of this substance; or, as the phenomenon is called in physiological language, a differentiation. Each of these differentiated divisions presently begins itself to exhibit some contrast of parts: and by and by these secondary differentiations become as definite as the original one. This process is continuously repeated – is simultaneously going on in all parts of the growing embryo; and by endless such differentiations there is finally produced that complex combination of tissues and organs constituting the adult animal or plant. This is the history of all organisms whatever. It is settled beyond dispute that organic progress consists in a change from the homogeneous to the heterogeneous.

Now, we propose in the first place to show, that this law of organic progress is the law of all progress. Whether it be in the development of the Earth, in the development of Life upon its surface, in the development of Society, of Government, of Manufactures, of Commerce, of Language, Literature, Science, Art, this same evolution of the simple into the complex, through successive differentiations, holds throughout. From the earliest traceable cosmical changes down to the latest results of civilization, we shall find that the transformation of the homogeneous into the heterogeneous, is that in which progress essentially consists.

With the view of showing that *if* the Nebular Hypothesis be true, the genesis of the solar system supplies one illustration of this law, let us assume that the matter of which the sun and planets consist was once in a diffused form; and that from the gravitation of its atoms there resulted a gradual concentration. By the hypothesis, the solar system in its nascent state existed as an indefinitely extended and nearly homogeneous medium – a medium almost homogeneous in density, in temperature, and in other physical attributes. The first change in the direction of increased aggregation, brought a contrast in density and a contrast in temperature, between the interior and the exterior of this mass. Simultaneously the drawing in of outer parts caused motions ending in rotation round a centre with various angular velocities. These differentiations increased in number and degree until there was evolved the organized group of sun, planets, and satellites, which we now know – a group which presents numerous contrasts of structure and action among its members. There are the immense contrasts between the sun and the planets, in bulk and in weight; as well as the subordinate contrasts between one planet and another, and between the planets and their satellites. There is the similarly-marked contrast between the sun as almost stationary (relatively to the other members of the Solar System), and the planets as moving round him with great velocity: while there are the secondary contrasts between the velocities and periods of the several planets, and between their simple revolutions and the double ones of their satellites, which have to move round their primaries while moving round the sun. There is the yet further strong contrast between the sun and the planets in respect of temperature; and there is good reason to suppose that the planets and satellites differ from each other in their proper heats, as well as in the amounts of heat they receive from the sun. When we bear in mind that, in addition to these various contrasts, the planets and satellites also differ in respect to their distances from each other and their primary; in respect to the inclinations of their orbits, the inclinations of their axes, their times of rotation on their axes, their specific gravities, and their physical constitutions; we see what a high degree of heterogeneity the solar system exhibits, when compared with the almost complete homogeneity of the nebulous mass out of which it is supposed to have originated.

Passing from this hypothetical illustration, which must be taken for what it is worth, without prejudice to the general argument, let us descend to a more certain order of evidence. It is now generally agreed among geologists and physicists that the Earth was at one time a mass of molten matter. If so, it was at that time relatively homogeneous in consistence, and, in virtue of the circulation which takes place in heated fluids, must have been comparatively homogeneous in temperature;

and it must have been surrounded by an atmosphere consisting partly of the elements of air and water, and partly of those various other elements which are among the more ready to assume gaseous forms at high temperatures. That slow cooling by radiation which is still going on at an inappreciable rate, and which, though originally far more rapid than now, necessarily required an immense time to produce any decided change, must ultimately have resulted in the solidification of the portion most able to part with its heat – namely, the surface. In the thin crust thus formed we have the first marked differentiation. A still further cooling, a consequent thickening of this crust, and an accompanying deposition of all solidifiable elements contained in the atmosphere, must finally have been followed by the condensation of the water previously existing as vapour. A second marked differentiation must thus have arisen; and as the condensation must have taken place on the coolest parts of the surface – namely, about the poles – there must thus have resulted the first geographical distinction of parts. To these illustrations of growing heterogeneity, which, though deduced from known physical laws, may be regarded as more or less hypothetical, Geology adds an extensive series that have been inductively established. Investigations show that the Earth has been continually becoming more heterogeneous in virtue of the multiplication of sedimentary strata which form its crust; also, that it has been becoming more heterogeneous in respect of the composition of these strata, the later of which, being made from the detritus of the earlier, are many of them rendered highly complex by the mixture of materials they contain; and further, that this heterogeneity has been vastly increased by the actions of the Earth's still molten nucleus upon its envelope, whence have resulted not only many kinds of igneous rocks, but the tilting up of sedimentary strata at all angles, the formation of faults and metallic veins, the production of endless dislocations and irregularities. Yet again, geologists teach us that the Earth's surface has been growing more varied in elevation – that the most ancient mountain systems are the smallest, and the Andes and Himalayas the most modern; while in all probability there have been corresponding changes in the bed of the ocean. As a consequence of these ceaseless differentiations, we now find that no considerable portion of the Earth's exposed surface is like any other portion, either in contour, in geologic structure, or in chemical composition; and that in most parts it changes from mile to mile in all these characters. Moreover, there has been simultaneously going on a differentiation of climates. As fast as the Earth cooled and its crust solidified, there arose appreciable differences in temperature between those parts of its surface more exposed to the sun and those less exposed. As the cooling progressed, these differences became more pronounced; until there finally resulted those marked contrasts between regions of perpetual ice and snow, regions where winter and summer alternately reign for periods varying according to the latitude, and regions where summer follows summer with scarcely an appreciable variation. At the same time the many and varied elevations and subsidences of portions of the Earth's crust, bringing about the present irregular distribution of land and sea, have entailed modifications of climate beyond those dependent on latitude; while a yet further series of such modifications have been produced by increasing differences of elevation in the land, which have in sundry places brought arctic, temperate, and tropical climates to within a few miles of one another. And the general outcome of these changes is, that not only has every extensive region its own meteorologic conditions, but that every locality in each region differs more or less from others in those conditions; as in its structure, its contour, its soil. Thus, between our existing Earth, the phenomena of whose crust neither geographers, geologists, mineralogists, nor meteorologists have yet enumerated, and the molten globe out of which it was evolved, the contrast in heterogeneity is extreme.

When from the Earth itself we turn to the plants and animals which have lived, or still live, upon its surface, we find ourselves in some difficulty from lack of facts. That every existing organism has been developed out of the simple into the complex, is indeed the first established truth of all; and that every organism which existed in past times was similarly developed, is an inference no physiologist will hesitate to draw. But when we pass from individual forms of life to Life in general, and inquire whether the same law is seen in the *ensemble* of its manifestations, – whether modern plants and animals are of more heterogeneous structure than ancient ones, and whether the Earth's present Flora and Fauna are more heterogeneous than the Flora and Fauna of the past, – we find the evidence so fragmentary, that every conclusion is open to dispute. Three-fifths of the Earth's surface being covered by water; a great part of the exposed land being inaccessible to, or untravelled by, the geologist; the greater part of the remainder having been scarcely more than glanced at; and even the most familiar portions, as England, having been so imperfectly explored that a new series of strata has been added within these four years, – it is impossible for us to say with certainty what creatures have, and what have not, existed at any particular period. Considering the perishable nature of many of the lower organic forms, the metamorphosis of numerous sedimentary strata, and the great gaps occurring among the rest, we shall see further reason for distrusting our deductions. On the one hand, the repeated discovery of vertebrate remains in strata previously supposed to contain none, – of reptiles where only fish were thought to exist, – of mammals where it was believed there were no creatures higher than reptiles, – renders it daily more manifest how small is the value of negative evidence. On the other hand, the worthlessness of the assumption that we have discovered the earliest, or anything like the earliest, organic remains, is becoming equally clear. That the oldest known sedimentary rocks have been greatly changed by igneous action, and that still older ones have been totally transformed by it, is becoming undeniable. And the fact that sedimentary strata earlier than any we know, have been melted up, being admitted, it must also be admitted that we cannot say how far back in time this destruction of sedimentary strata has been going on. Thus the title *Palæozoic*, as applied to the earliest known fossiliferous strata, involves a *petitio principii*; and, for aught we know to the contrary, only the last few chapters of the Earth's biological history may have come down to us. On neither side, therefore, is the evidence conclusive. Nevertheless we cannot but think that, scanty as they are, the facts, taken altogether, tend to show both that the more heterogeneous organisms have been evolved in the later geologic periods, and that Life in general has been more heterogeneously manifested as time has advanced. Let us cite, in illustration, the one case of the *Vertebrata*. The earliest known vertebrate remains are those of Fishes; and Fishes are the most homogeneous of the vertebrata. Later and more heterogeneous are Reptiles. Later still, and more heterogeneous still, are Birds and Mammals. If it be said that the Palæozoic deposits, not being estuary deposits, are not likely to contain the remains of terrestrial vertebrata, which may nevertheless have existed at that era, we reply that we are merely pointing to the leading facts, *such as they are*. But to avoid any such criticism, let us take the mammalian subdivision only. The earliest known remains of mammals are those of small marsupials, which are the lowest of the mammalian type; while, conversely, the highest of the mammalian type – Man – is the most recent. The evidence that the vertebrate fauna, as a whole, has become more heterogeneous, is considerably stronger. To the argument that the vertebrate fauna of the Palæozoic period, consisting, so far as we know, entirely of Fishes, was less heterogeneous than the modern vertebrate fauna, which includes Reptiles, Birds, and Mammals, of multitudinous genera, it may be replied, as before, that estuary deposits of the Palæozoic period, could we find them, might contain other orders of vertebrata. But no such reply can be made to the argument that whereas the marine vertebrata of the Palæozoic period consisted entirely of cartilaginous fishes, the marine vertebrata of later periods include numerous genera of osseous fishes; and that, therefore, the later marine vertebrate faunas are more heterogeneous than the oldest known one. Nor, again, can any such reply be made to the fact that there are far more numerous orders and genera of mammalian remains in the tertiary formations than in the secondary formations. Did we wish merely to make out the best case, we might dwell upon the opinion of Dr. Carpenter, who says that "the general facts of Palæontology appear to sanction the belief, that *the same plan* may be traced out in what may be called *the general life of the globe*, as in *the individual life* of every one of the forms of organized being which now people it." Or we might quote, as decisive, the judgment of Professor Owen, who holds that the earlier examples of each group of creatures severally departed less widely from archetypal generality than the later examples – were severally less unlike the fundamental form common to the group as a whole; and thus constituted a less heterogeneous group of creatures. But in deference to an authority for whom we have the highest respect, who considers that the evidence at present obtained does not justify a verdict either way, we are content to leave the question open.[2]

Whether an advance from the homogeneous to the heterogeneous is or is not displayed in the biological history of the globe, it is clearly enough displayed in the progress of the latest and most heterogeneous creature – Man. It is true alike that, during the period in which the Earth has been peopled, the human organism has grown more heterogeneous among the civilized divisions of the species; and that the species, as a whole, has been growing more heterogeneous in virtue of the multiplication of races and the differentiation of these races from each other. In proof of the first of these positions, we may cite the fact that, in the relative development of the limbs, the civilized man departs more widely from the general type of the placental mammalia than do the lower human races. While often possessing well-developed body and arms, the Australian has very small legs: thus reminding us of the chimpanzee and the gorilla, which present no great contrasts

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[2] Since this was written (in 1857) the advance of paleontological discovery, especially in America, has shown conclusively, in respect of certain groups of vertebrates, that higher types have arisen by modifications of lower; so that, in common with others, Prof. Huxley, to whom the above allusion is made, now admits, or rather asserts, biological progression, and, by implication, that there have arisen more heterogeneous organic forms and a more heterogeneous assemblage of organic forms.

in size between the hind and fore limbs. But in the European, the greater length and massiveness of the legs have become marked – the fore and hind limbs are more heterogeneous. Again, the greater ratio which the cranial bones bear to the facial bones illustrates the same truth. Among the vertebrata in general, progress is marked by an increasing heterogeneity in the vertebral column, and more especially in the segments constituting the skull: the higher forms being distinguished by the relatively larger size of the bones which cover the brain, and the relatively smaller size of those which form the jaws, &c. Now this characteristic, which is stronger in Man than in any other creature, is stronger in the European than in the savage. Moreover, judging from the greater extent and variety of faculty he exhibits, we may infer that the civilized man has also a more complex or heterogeneous nervous system than the uncivilized man: and, indeed, the fact is in part visible in the increased ratio which his cerebrum bears to the subjacent ganglia, as well as in the wider departure from symmetry in its convolutions. If further elucidation be needed, we may find it in every nursery. The infant European has sundry marked points of resemblance to the lower human races; as in the flatness of the alæ of the nose, the depression of its bridge, the divergence and forward opening of the nostrils, the form of the lips, the absence of a frontal sinus, the width between the eyes, the smallness of the legs. Now, as the developmental process by which these traits are turned into those of the adult European, is a continuation of that change from the homogeneous to the heterogeneous displayed during the previous evolution of the embryo, which every anatomist will admit; it follows that the parallel developmental process by which the like traits of the barbarous races have been turned into those of the civilized races, has also been a continuation of the change from the homogeneous to the heterogeneous. The truth of the second position – that Mankind, as a whole, have become more heterogeneous – is so obvious as scarcely to need illustration. Every work on Ethnology, by its divisions and subdivisions of races, bears testimony to it. Even were we to admit the hypothesis that Mankind originated from several separate stocks, it would still remain true, that as, from each of these stocks, there have sprung many now widely-different tribes, which are proved by philological evidence to have had a common origin, the race as a whole is far less homogeneous than it once was. Add to which, that we have, in the Anglo-Americans, an example of a new variety arising within these few generations; and that, if we may trust to the descriptions of observers, we are likely soon to have another such example in Australia.

On passing from Humanity under its individual form, to Humanity as socially embodied, we find the general law still more variously exemplified. The change from the homogeneous to the heterogeneous is displayed in the progress of civilization as a whole, as well as in the progress of every nation; and is still going on with increasing rapidity. As we see in existing barbarous tribes, society in its first and lowest form is a homogeneous aggregation of individuals having like powers and like functions: the only marked difference of function being that which accompanies difference of sex. Every man is warrior, hunter, fisherman, tool-maker, builder; every woman performs the same drudgeries. Very early, however, in the course of social evolution, there arises an incipient differentiation between the governing and the governed. Some kind of chieftainship seems coeval with the first advance from the state of separate wandering families to that of a nomadic tribe. The authority of the strongest or the most cunning makes itself felt among a body of savages as in a herd of animals, or a posse of schoolboys. At first, however, it is indefinite, uncertain; is shared by others of scarcely inferior power; and is unaccompanied by any difference in occupation or style of living: the first ruler kills his own game, makes his own weapons, builds his own hut, and, economically considered, does not differ from others of his tribe. Gradually, as the tribe progresses, the contrast between the governing and the governed grows more decided. Supreme power becomes hereditary in one family; the head of that family, ceasing to provide for his own wants, is served by others; and he begins to assume the sole office of ruling. At the same time there has been arising a co-ordinate species of government – that of Religion. As all ancient records and traditions prove, the earliest rulers are regarded as divine personages. The maxims and commands they uttered during their lives are held sacred after their deaths, and are enforced by their divinely-descended successors; who in their turns are promoted to the pantheon of the race, here to be worshipped and propitiated along with their predecessors: the most ancient of whom is the supreme god, and the rest subordinate gods. For a long time these connate forms of government – civil and religious – remain closely associated. For many generations the king continues to be the chief priest, and the priesthood to be members of the royal race. For many ages religious law continues to include more or less of civil regulation, and civil law to possess more or less of religious sanction; and even among the most advanced nations these two controlling agencies are by no means completely separated from each other. Having a common root with these, and gradually diverging from them, we find yet another controlling agency – that of Ceremonial usages. All titles of honour are originally the names of the god-king; afterwards of the god and the king; still later of persons of high rank; and finally come, some of them, to be used between man and man. All forms of complimentary address were at first the expressions of submission from prisoners to their conqueror, or from subjects to their ruler, either human or divine – expressions which were afterwards used to propitiate subordinate authorities, and slowly descended into ordinary intercourse. All modes of salutation were once obeisances made before the monarch and used in worship of him after his death. Presently others of the god-descended race were similarly saluted; and by degrees some of the salutations have become the due of all.[3] Thus, no sooner

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[3] For detailed proof of these assertions see essay on "Manners and Fashion."

does the originally-homogeneous social mass differentiate into the governed and the governing parts, than this last exhibits an incipient differentiation into religious and secular – Church and State; while at the same time there begins to be differentiated from both, that less definite species of government which rules our daily intercourse – a species of government which, as we may see in heralds' colleges, in books of the peerage, in masters of ceremonies, is not without a certain embodiment of its own. Each of these is itself subject to successive differentiations. In the course of ages, there arises, as among ourselves, a highly complex political organization of monarch, ministers, lords and commons, with their subordinate administrative departments, courts of justice, revenue offices, &c., supplemented in the provinces by municipal governments, county governments, parish or union governments – all of them more or less elaborated. By its side there grows up a highly complex religious organization, with its various grades of officials, from archbishops down to sextons, its colleges, convocations, ecclesiastical courts, &c.; to all which must be added the ever-multiplying independent sects, each with its general and local authorities. And at the same time there is developed a highly complex aggregation of customs, manners, and temporary fashions, enforced by society at large, and serving to control those minor transactions between man and man which are not regulated by civil and religious law. Moreover, it is to be observed that this increasing heterogeneity in the governmental appliances of each nation, has been accompanied by an increasing heterogeneity in the assemblage of governmental appliances of different nations: all nations being more or less unlike in their political systems and legislation, in their creeds and religious institutions, in their customs and ceremonial usages.

Simultaneously there has been going on a second differentiation of a more familiar kind; that, namely, by which the mass of the community has been segregated into distinct classes and orders of workers. While the governing part has undergone the complex development above detailed, the governed part has undergone an equally complex development, which has resulted in that minute division of labour characterizing advanced nations. It is needless to trace out this progress from its first stages, up through the caste-divisions of the East and the incorporated guilds of Europe, to the elaborate producing and distributing organization existing among ourselves. It has been an evolution which, beginning with a tribe whose members severally perform the same actions each for himself, ends with a civilized community whose members severally perform different actions for each other; and an evolution which has transformed the solitary producer of any one commodity into a combination of producers who, united under a master, take separate parts in the manufacture of such commodity. But there are yet other and higher phases of this advance from the homogeneous to the heterogeneous in the industrial organization of society. Long after considerable progress has been made in the division of labour among different classes of workers, there is still little or no division of labour among the widely separated parts of the community: the nation continues comparatively homogeneous in the respect that in each district the same occupations are pursued. But when roads and other means of transit become numerous and good, the different districts begin to assume different functions, and to become mutually dependent. The calico manufacture locates itself in this county, the woollen-cloth manufacture in that; silks are produced here, lace there; stockings in one place, shoes in another; pottery, hardware, cutlery, come to have their special towns; and ultimately every locality becomes more or less distinguished from the rest by the leading occupation carried on in it. This subdivision of functions shows itself not only among the different parts of the same nation, but among different nations. That exchange of commodities which free-trade is increasing so largely, will ultimately have the effect of specializing, in a greater or less degree, the industry of each people. So that, beginning with a barbarous tribe, almost if not quite homogeneous in the functions of its members, the progress has been, and still is, towards an economic aggregation of the whole human race; growing ever more heterogeneous in respect of the separate functions assumed by separate nations, the separate functions assumed by the local sections of each nation, the separate functions assumed by the many kinds of makers and traders in each town, and the separate functions assumed by the workers united in producing each commodity.

The law thus clearly exemplified in the evolution of the social organism, is exemplified with equal clearness in the evolution of all products of human thought and action; whether concrete or abstract, real or ideal. Let us take Language as our first illustration.

The lowest form of language is the exclamation, by which an entire idea is vaguely conveyed through a single sound, as among the lower animals. That human language ever consisted solely of exclamations, and so was strictly homogeneous in respect of its parts of speech, we have no evidence. But that language can be traced down to a form in which nouns and verbs are its only elements, is an established fact. In the gradual multiplication of parts of speech out of these primary ones – in the differentiation of verbs into active and passive, of nouns into abstract and concrete – in the rise of distinctions of mood, tense, person, of number and case – in the formation of auxiliary verbs, of adjectives, adverbs, pronouns, prepositions, articles – in the divergence of those orders, genera, species, and varieties of parts of speech by which civilized races express minute modifications of meaning – we see a change from the homogeneous to the heterogeneous. Another aspect under which we may trace the development of language is the divergence of words having common origins. Philology early disclosed the truth that in all languages words may be grouped into families, the members of each of which are allied by their derivation. Names springing from a primitive root, themselves become the parents of other names still further modified. And by the aid of those systematic modes which presently arise, of making derivatives and forming compound terms, there is finally developed a tribe of words so heterogeneous in sound and meaning, that to the uninitiated it seems incredible they should be nearly related. Meanwhile from other roots there are being evolved other such tribes, until there results a language of some sixty thousand or more unlike words, signifying as many unlike objects, qualities, acts. Yet another way in which language in general advances from the homogeneous to the heterogeneous, is in the multiplication of languages. Whether all languages have grown from one stock, or whether, as some philologists think, they have grown from two or more stocks, it is clear that since large groups of languages, as the Indo-European, are of one parentage, they have become distinct through a process of continuous divergence. The same diffusion over the Earth's surface which has led to differentiations of race, has simultaneously led to differentiations of speech: a truth which we see further illustrated in each nation by the distinct dialects found in separate districts. Thus the progress of Language conforms to the general law, alike in the evolution of languages, in the evolution of families of words, and in the evolution of parts of speech.

On passing from spoken to written language, we come upon several classes of facts, having similar implications. Written language is connate with Painting and Sculpture; and at first all three are appendages of Architecture, and have a direct connection with the primary form of all Government – the theocratic. Merely noting by the way the fact that sundry wild races, as for example the Australians and the tribes of South Africa, are given to depicting personages and events upon the walls of caves, which are probably regarded as sacred places, let us pass to the case of the Egyptians. Among them, as also among the Assyrians, we find mural paintings used to decorate the temple of the god and the palace of the king (which were, indeed, originally identical); and as such they were governmental appliances in the same sense as state-pageants and religious feasts were. They were governmental appliances in another way: representing as they did the worship of the god, the triumphs of the god-king, the submission of his subjects, and the punishment of the rebellious. Further, they were governmental, as being the products of an art reverenced by the people as a sacred mystery. From the habitual use of this pictorial representation there grew up the but-slightly-modified practice of picture-writing – a practice which was found still extant among North American peoples at the time they were discovered. By abbreviations analogous to those still going on in our own written language, the most frequently-recurring of these pictured figures were successively simplified; and ultimately there grew up a system of symbols, most of which had but distant resemblances to the things for which they stood. The inference that the hieroglyphics of the Egyptians were thus produced, is confirmed by the fact that the picture-writing of the Mexicans was found to have given birth to a like family of ideographic forms; and among them, as among the Egyptians, these had been partially differentiated into the *kuriological* or imitative, and the *tropical* or symbolic; which were, however, used together in the same record. In Egypt, written language underwent a further differentiation, whence resulted the *hieratic* and the *epistolographic* or *enchorial*; both of which are derived from the original hieroglyphic. At the same time we find that for the expression of proper names, which could not be otherwise conveyed, signs having phonetic values were employed; and though it is alleged that the Egyptians never achieved complete alphabetic writing, yet it can scarcely be doubted that these phonetic symbols, occasionally used in aid of their ideographic ones, were the germs of an alphabetic system. Once having become separate from hieroglyphics, alphabetic writing itself underwent numerous differentiations – multiplied alphabets were produced; between most of which, however, more or less connection can still be traced. And in each civilized nation there has now grown up, for the representation of one set of sounds, several sets of written signs used for distinct purposes. Finally, from writing diverged printing; which, uniform in kind as it was at first, has since become multiform.

While written language was passing through its first stages of development, the mural decoration which contained its root was being differentiated into Painting and Sculpture. The gods, kings, men, and animals represented, were originally marked by indented outlines and coloured. In most cases these outlines were of such depth, and the object they circumscribed so far rounded and marked out in its leading parts, as to form a species of work intermediate between intaglio and bas-relief. In other cases we see an advance upon this: the raised spaces between the figures being chiselled off, and the figures themselves appropriately tinted, a painted bas-relief was produced. The restored Assyrian architecture at Sydenham exhibits this style of art carried to greater perfection – the persons and things represented, though still barbarously coloured, are carved out with more truth and in greater detail: and in the winged lions and bulls used for the angles of gateways, we may see a considerable advance towards a completely sculptured figure; which, nevertheless, is still coloured, and still forms part of the building. But while in Assyria the production of a statue proper seems to have been little, if at all, attempted, we may trace in Egyptian art the gradual separation of the sculptured figure from the wall. A walk through the collection in the British Museum shows this; while at the same time it affords an opportunity of observing the traces which the independent statues bear of their derivation from bas-relief: seeing that nearly all of them not only display that fusion of the legs with one another and of the arms with the body which is characteristic of bas-relief, but have the back united from head to foot with a block which stands in place of the original wall. Greece repeated the leading stages of this progress. On the friezes of Greek Temples, were coloured bas-reliefs representing sacrifices, battles, processions, games – all in some sort religious. The pediments contained painted sculptures more or less united with the tympanum, and having for subjects the triumphs of gods or heroes. Even statues definitely separated from buildings were coloured; and only in the later periods of Greek civilization does the differentiation of Sculpture from Painting appear to have become complete. In Christian art we may trace a parallel re-genesis. All early works of art throughout Europe were religious in subject – represented Christs, crucifixions, virgins, holy families, apostles, saints. They formed integral parts of church architecture, and were among the means of exciting worship; as in Roman Catholic countries they still are. Moreover, the sculptured figures of Christ on the cross, of virgins, of saints, were coloured; and it needs but to call to mind the painted madonnas still abundant in continental churches and highways, to perceive the significant fact that Painting and Sculpture continue in closest connection with each other where they continue in closest connection with their parent. Even when Christian sculpture became differentiated from painting, it was still religious and governmental in its subjects – was used for tombs in churches and statues of kings; while, at the same time, painting, where not purely ecclesiastical, was applied to the decoration of palaces, and besides representing royal personages, was mostly devoted to sacred legends. Only in recent times have painting and sculpture become quite separate and mainly secular. Only within these few centuries has Painting been divided into historical, landscape, marine, architectural, genre, animal, still-life, &c.; and Sculpture grown heterogeneous in respect of the variety of real and ideal subjects with which it occupies itself.

Strange as it seems then, we find that all forms of written language, of Painting, and of Sculpture, have a common root in the politico-religious decorations of ancient temples and palaces. Little resemblance as they now have, the landscape that hangs against the wall, and the copy of the *Times* lying on the table, are remotely akin. The brazen face of the knocker which the postman has just lifted, is related not only to the woodcuts of the *Illustrated London News* which he is delivering, but to the characters of the *billet-doux* which accompanies it. Between the painted window, the prayer-book on which its light falls, and the adjacent monument, there is consanguinity. The effigies on our coins, the signs over shops, the coat of arms outside the carriage panel, and the placards inside the omnibus, are, in common with dolls and paper-hangings, lineally descended from the rude sculpture-paintings in which ancient peoples represented the triumphs and worship of their god-kings. Perhaps no example can be given which more vividly illustrates the multiplicity and heterogeneity of the products that in course of time may arise by successive differentiations from a common stock.

Before passing to other classes of facts, it should be observed that the evolution of the homogeneous into the heterogeneous is displayed not only in the separation of Painting and Sculpture from Architecture and from each other, and in the greater variety of subjects they embody, but it is further shown in the structure of each work. A modern picture or statue is of far more heterogeneous nature than an ancient one. An Egyptian sculpture-fresco usually represents all its figures as at the same distance from the eye; and so is less heterogeneous than a painting that represents them as at various distances from the eye. It exhibits all objects as exposed to the same degree of light; and so is less heterogeneous than a painting which exhibits its different objects and different parts of each object as in different degrees of light. It uses chiefly the primary colours, and these in their full intensities; and so is less heterogeneous than a painting which, introducing the primary colours but sparingly, employs numerous intermediate tints, each of heterogeneous composition, and differing from the rest not only in quality but in strength. Moreover, we see in these early works great uniformity of conception. The same arrangement of figures is perpetually reproduced – the same actions, attitudes, faces, dresses. In Egypt the modes of representation were so fixed that it was sacrilege to introduce a novelty. The Assyrian bas-reliefs display parallel characters. Deities, kings, attendants, winged-figures and animals, are time after time depicted in like positions, holding like implements, doing like things, and with like expression or non-expression of face. If a palm-grove is introduced, all the trees are of the same height, have the same number of leaves, and are equidistant. When water is imitated, each wave is a counterpart of the rest; and the fish, almost always of one kind, are evenly distributed over the surface. The beards of the kings, the gods, and the winged-figures, are everywhere similar; as are the manes of the lions, and equally so those of the horses. Hair is represented throughout by one form of curl. The king's beard is quite architecturally built up of compound tiers of uniform curls, alternating with twisted tiers placed in a transverse direction, and arranged with perfect regularity; and the terminal tufts of the bulls' tails are represented in exactly the same manner. Without tracing out analogous facts in early Christian art, in which, though less striking, they are still visible, the advance in heterogeneity will be sufficiently manifest on remembering that in the pictures of our own day the composition is endlessly varied; the attitudes, faces, expressions, unlike; the subordinate objects different in sizes, forms, textures; and more or less of contrast even in the smallest details. Or, if we compare an Egyptian statue, seated bolt upright on a block, with hands on knees, fingers parallel, eyes looking straight forward, and the two sides perfectly symmetrical in every particular, with a statue of the advanced Greek school or the modern school, which is asymmetrical in respect of the attitude of the head, the body, the limbs, the arrangement of the hair, dress, appendages, and in its relations to neighbouring objects, we shall see the change from the homogeneous to the heterogeneous clearly manifested.

In the co-ordinate origin and gradual differentiation of Poetry, Music, and Dancing, we have another series of illustrations. Rhythm in words, rhythm in sounds, and rhythm in motions, were in the beginning parts of the same thing, and have only in process of time become separate things. Among existing barbarous tribes we find them still united. The dances of savages are accompanied by some kind of monotonous chant, the clapping of hands, the striking of rude instruments: there are measured movements, measured words, and measured tones. The early records of historic races similarly show these three forms of metrical action united in religious festivals. In the Hebrew writings we read that the triumphal ode composed by Moses on the defeat of the Egyptians, was sung to an accompaniment of dancing and timbrels. The Israelites danced and sung "at the inauguration of the golden calf. And as it is generally agreed that this representation of the Deity was borrowed from the mysteries of Apis, it is probable that the dancing was copied from that of the Egyptians on those occasions." Again, in Greece the like relation is everywhere seen: the original type being there, as probably in other cases, a simultaneous chanting and mimetic representation of the life and adventures of the hero or the god. The Spartan dances were accompanied by hymns and songs; and in general the Greeks had "no festivals or religious assemblies but what were accompanied with songs and dances" – both of them being forms of worship used before altars. Among the Romans, too, there were sacred dances: the Salian and Lupercalian being named as of that kind. And even in Christian countries, as at Limoges, in comparatively recent times, the people have danced in the choir in honour of a saint. The incipient separation of these once-united arts from each other and from religion, was early visible in Greece. Probably diverging from dances partly religious, partly warlike, as the Corybantian, came the war-dances proper, of which there were various kinds. Meanwhile Music and Poetry, though still united, came to have an existence separate from Dancing. The primitive Greek poems, religious in subject, were not recited but chanted; and though at first the chant of the poet was accompanied by the dance of the chorus, it ultimately grew into independence. Later still, when the poem had been differentiated into epic and lyric – when it became the custom to sing the lyric and recite the epic – poetry proper was born. As during the same period musical instruments were being multiplied, we may presume that music came to have an existence apart from words. And both of them were beginning to assume other forms besides the religious. Facts having like implications might be cited from the histories of later times and peoples; as the practices of our own early minstrels, who sang to the harp heroic narratives versified by themselves to music of their own composition: thus uniting the now separate offices of poet, composer, vocalist, and instrumentalist. But, without further illustration, the common origin and gradual differentiation of Dancing, Poetry, and Music will be sufficiently manifest.

The advance from the homogeneous to the heterogeneous is displayed not only in the separation of these arts from each other and from religion, but also in the multiplied differentiations which each of them afterwards undergoes. Not to dwell upon the numberless kinds of dancing that have, in course of time, come into use: and not to occupy space in detailing the progress of poetry, as seen in the development of the various forms of metre, of rhyme, and of general organization; let us confine our attention to music as a type of the group. As implied by the customs of still extant barbarous races, the first musical instruments were, without doubt, percussive – sticks, calabashes, tom-toms – and were used simply to mark the time of the dance; and in this constant repetition of the same sound, we see music in its most homogeneous form. The Egyptians had a lyre with three strings. The early lyre of the Greeks had four, constituting their tetrachord. In course of some centuries lyres of seven and eight strings were employed; and, by the expiration of a thousand years, they had advanced to their "great system" of the double octave. Through all which changes there of course arose a greater heterogeneity of melody. Simultaneously there came into use the different modes – Dorian, Ionian, Phrygian, Æolian, and Lydian – answering to our keys; and of these there were ultimately fifteen. As yet, however, there was but little heterogeneity in the time of their music. Instrumental music being at first merely the accompaniment of vocal music, and vocal music being subordinated to words, – the singer being also the poet, chanting his own compositions and making the lengths of his notes agree with the feet of his verses, – there resulted a tiresome uniformity of measure, which, as Dr.

Burney says, "no resources of melody could disguise." Lacking the complex rhythm obtained by our equal bars and unequal notes, the only rhythm was that produced by the quantity of the syllables, and was of necessity comparatively monotonous. And further, it maybe observed that the chant thus resulting, being like recitative, was much less clearly differentiated from ordinary speech than is our modern song. Nevertheless, in virtue of the extended range of notes in use, the variety of modes, the occasional variations of time consequent on changes of metre, and the multiplication of instruments, music had, towards the close of Greek civilization, attained to considerable heterogeneity – not indeed as compared with our music, but as compared with that which preceded it. Still, there existed nothing but melody: harmony was unknown. It was not until Christian church-music had reached some development, that music in parts was evolved; and then it came into existence through a very unobtrusive differentiation. Difficult as it may be to conceive *a priori* how the advance from melody to harmony could take place without a sudden leap, it is none the less true that it did so. The circumstance which prepared the way for it was the employment of two choirs singing alternately the same air. Afterwards it became the practice – very possibly first suggested by a mistake – for the second choir to commence before the first had ceased; thus producing a fugue. With the simple airs then in use, a partially-harmonious fugue might not improbably thus result: and a very partially-harmonious fugue satisfied the ears of that age, as we know from still preserved examples. The idea having once been given, the composing of airs productive of fugal harmony would naturally grow up, as in some way it *did* grow up, out of this alternate choir-singing. And from the fugue to concerted music of two, three, four, and more parts, the transition was easy. Without pointing out in detail the increasing complexity that resulted from introducing notes of various lengths, from the multiplication of keys, from the use of accidentals, from varieties of time, and so forth, it needs but to contrast music as it is, with music as it was, to see how immense is the increase of heterogeneity. We see this if, looking at music in its *ensemble*, we enumerate its many different genera and species – if we consider the divisions into vocal, instrumental, and mixed; and their subdivisions into music for different voices and different instruments – if we observe the many forms of sacred music, from the simple hymn, the chant, the canon, motet, anthem, &c., up to the oratorio; and the still more numerous forms of secular music, from the ballad up to the serenata, from the instrumental solo up to the symphony. Again, the same truth is seen on comparing any one sample of aboriginal music with a sample of modern music – even an ordinary song for the piano; which we find to be relatively very heterogeneous, not only in respect of the variety in the pitches and in the lengths of the notes, the number of different notes sounding at the same instant in company with the voice, and the variations of strength with which they are sounded and sung, but in respect of the changes of key, the changes of time, the changes of *timbre* of the voice, and the many other modifications of expression. While between the old monotonous dance-chant and a grand opera of our own day, with its endless orchestral complexities and vocal combinations, the contrast in heterogeneity is so extreme that it seems scarcely credible that the one should have been the ancestor of the other.

Were they needed, many further illustrations might be cited. Going back to the early time when the deeds of the god-king were recorded in picture-writings on the walls of temples and palaces, and so constituted a rude literature, we might trace the development of Literature through phases in which, as in the Hebrew Scriptures, it presents in one work theology, cosmogony, history, biography, law, ethics, poetry; down to its present heterogeneous development, in which its separated divisions and subdivisions are so numerous and varied as to defy complete classification. Or we might trace out the evolution of Science; beginning with the era in which it was not yet differentiated from Art, and was, in union with Art, the handmaid of Religion; passing through the era in which the sciences were so few and rudimentary, as to be simultaneously cultivated by the same men; and ending with the era in which the genera and species are so numerous that few can enumerate them, and no one can adequately grasp even one genus. Or we might do the like with Architecture, with the Drama, with Dress. But doubtless the reader is already weary of illustrations; and our promise has been amply fulfilled. Abundant proof has been given that the law of organic development formulated by von Baer, is the law of all development. The advance from the simple to the complex, through a process of successive differentiations, is seen alike in the earliest changes of the Universe to which we can reason our way back, and in the earliest changes which we can inductively establish; it is seen in the geologic and climatic evolution of the Earth; it is seen in the unfolding of every single organism on its surface, and in the multiplication of kinds of organisms; it is seen in the evolution of Humanity, whether contemplated in the civilized individual, or in the aggregate of races; it is seen in the evolution of Society in respect alike of its political, its religious, and its economical organization; and it is seen in the evolution of all those endless concrete and abstract products of human activity which constitute the environment of our daily life. From the remotest past which Science can fathom, up to the novelties of yesterday, that in which progress essentially consists, is the transformation of the homogeneous into the heterogeneous.

And now, must not this uniformity of procedure be a consequence of some fundamental necessity? May we not rationally seek for some all-pervading principle which determines this all-pervading process of things? Does not the universality of the *law* imply a universal *cause*?

That we can comprehend such cause, noumenally considered, is not to be supposed. To do this would be to solve that ultimate mystery which must ever transcend human intelligence. But it still may be possible for us to reduce the law of all progress, above set forth, from the condition of an empirical generalization, to the condition of a rational generalization. Just as it was possible to interpret Kepler's laws as necessary consequences of the law of gravitation; so it may be possible to interpret this law of progress, in its multiform manifestations, as the necessary consequence of some similarly universal principle. As gravitation was assignable as the *cause* of each of the groups of phenomena which Kepler generalized; so may some equally simple attribute of things be assignable as the cause of each of the groups of phenomena generalized in the foregoing pages. We may be able to affiliate all these varied evolutions of the homogeneous into the heterogeneous, upon certain facts of immediate experience, which, in virtue of endless repetition, we regard as necessary.

The probability of a common cause, and the possibility of formulating it, being granted, it will be well, first, to ask what must be the general characteristics of such cause, and in what direction we ought to look for it. We can with certainty predict that it has a high degree of abstractness; seeing that it is common to such infinitely-varied phenomena. We need not expect to see in it an obvious solution of this or that form of progress; because it is equally concerned with forms of progress bearing little apparent resemblance to them: its association with multiform orders of facts, involves its dissociation from any particular order of facts. Being that which determines progress of every kind – astronomic, geologic, organic, ethnologic, social, economic, artistic, &c. – it must be involved with some fundamental trait displayed in common by these; and must be expressible in terms of this fundamental trait. The only obvious respect in which all kinds of progress are alike, is, that they are modes of *change*; and hence, in some characteristic of changes in general, the desired solution will probably be found. We may suspect *a priori* that in some universal law of change lies the explanation of this universal transformation of the homogeneous into the heterogeneous.

Thus much premised, we pass at once to the statement of the law, which is this: —*Every active force produces more than one change – every cause produces more than one effect.*

To make this proposition comprehensible, a few examples must be given. When one body strikes another, that which we usually regard as the effect, is a change of position or motion in one or both bodies. But a moment's thought shows us that this is a very incomplete view of the matter. Besides the visible mechanical result, sound is produced; or, to speak accurately, a vibration in one or both bodies, which is communicated to the surrounding air; and under some circumstances we call this the effect. Moreover, the air has not only been made to undulate, but has had currents caused in it by the transit of the bodies. Further, there is a disarrangement of the particles of the two bodies in the neighbourhood of their point of collision; amounting, in some cases, to a visible condensation. Yet more, this condensation is accompanied by the disengagement of heat. In some cases a spark – that is, light – results, from the incandescence of a portion struck off; and sometimes this incandescence is associated with chemical combination. Thus, by the mechanical force expended in the collision, at least five, and often more, different kinds of changes have been produced. Take, again, the lighting of a candle. Primarily this is a chemical change consequent on a rise of temperature. The process of combination having once been started by extraneous heat, there is a continued formation of carbonic acid, water, &c. – in itself a result more complex than the extraneous heat that first caused it. But accompanying this process of combination there is a production of heat; there is a production of light; there is an ascending column of hot gases generated; there are inflowing currents set going in the surrounding air. Moreover, the complicating of effects does not end here: each of the several changes produced becomes the parent of further changes. The carbonic acid given off will by and by combine with some base; or under the influence of sunshine give up its carbon to the leaf of a plant. The water will modify the hygrometric state of the air around; or, if the current of hot gases containing it comes against a cold body, will be condensed: altering the temperature of the surface it covers. The heat given out melts the subjacent tallow, and expands whatever it warms. The light, falling on various substances, calls forth from them reactions by which its composition is modified; and so divers colours are produced. Similarly even with these secondary actions, which may be traced out into ever-multiplying ramifications, until they become too minute to be appreciated.

And thus it is with all changes whatever. No case can be named in which an active force does not evolve forces of several kinds, and each of these, other groups of forces. Universally the effect is more complex than the cause.

Doubtless the reader already foresees the course of our argument. This multiplication of effects, which is displayed in every event of to-day, has been going on from the beginning; and is true of the grandest phenomena of the universe as of the most insignificant. From the law that every active force produces more than one change, it is an inevitable corollary that during the past there has been an ever-growing complication of things. Throughout creation there must have gone on, and must still go on, a never-ceasing transformation of the homogeneous into the heterogeneous. Let us trace this truth in detail.

Without committing ourselves to it as more than a speculation, though a highly probable one, let us again commence with the evolution of the Solar System out of a nebulous medium. The hypothesis is that from the mutual attraction of the molecules of a diffused mass whose form is unsymmetrical, there results not only condensation but rotation. While the condensation and the rate of rotation go on increasing, the approach of the molecules is necessarily accompanied by an increasing temperature. As the temperature rises, light begins to be evolved; and ultimately there results a revolving sphere of fluid matter radiating intense heat and light – a sun. There are reasons for believing that, in consequence of the higher tangential velocity originally possessed by the outer parts of the condensing nebulous mass, there will be occasional detachments of rotating rings; and that, from the breaking up of these nebulous rings, there will arise masses which in the course of their condensation repeat the actions of the parent mass, and so produce planets and their satellites – an inference strongly supported by the still extant rings of Saturn. Should it hereafter be satisfactorily shown that planets and satellites were thus generated, a striking illustration will be afforded of the highly heterogeneous effects produced by the primary homogeneous cause; but it will serve our present purpose to point to the fact that from the mutual attraction of the particles of an irregular nebulous mass there result condensation, rotation, heat, and light.

It follows as a corollary from the Nebular Hypothesis, that the Earth must once have been incandescent; and whether the Nebular Hypothesis be true or not, this original incandescence of the Earth is now inductively established – or, if not established, at least rendered so highly probable that it is an accepted geological doctrine. Let us look first at the astronomical attributes of this once molten globe. From its rotation there result the oblateness of its form, the alternations of day and night, and (under the influence of the moon and in a smaller degree the sun) the tides, aqueous and atmospheric. From the inclination of its axis, there result the many differences of the seasons, both simultaneous and successive, that pervade its surface, and from the same cause joined with the action of the moon on the equatorial protuberance there results the precession of the equinoxes. Thus the multiplication of effects is obvious. Several of the differentiations due to the gradual cooling of the Earth have been already noticed – as the formation of a crust, the solidification of sublimed elements, the precipitation of water, &c., – and we here again refer to them merely to point out that they are simultaneous effects of the one cause, diminishing heat. Let us now, however, observe the multiplied changes afterwards arising from the continuance of this one cause. The cooling of the Earth involves its contraction. Hence the solid crust first formed is presently too large for the shrinking nucleus; and as it cannot support itself, inevitably follows the nucleus. But a spheroidal envelope cannot sink down into contact with a smaller internal spheroid, without disruption: it must run into wrinkles as the rind of an apple does when the bulk of its interior decreases from evaporation. As the cooling progresses and the envelope thickens, the ridges consequent on these contractions will become greater, rising ultimately into hills and mountains; and the later systems of mountains thus produced will not only be higher, as we find them to be, but will be longer, as we also find them to be. Thus, leaving out of view other modifying forces, we see what immense heterogeneity of surface has arisen from the one cause, loss of heat – a heterogeneity which the telescope shows us to be paralleled on the face of Mars, and which in the moon too, where aqueous and atmospheric agencies have been absent, it reveals under a somewhat different form. But we have yet to notice another kind of heterogeneity of surface similarly and simultaneously caused. While the Earth's crust was still thin, the ridges produced by its contraction must not only have been small, but the spaces between these ridges must have rested with great evenness upon the subjacent liquid spheroid; and the water in those arctic and antarctic regions in which it first condensed, must have been evenly distributed. But as fast as the crust thickened and gained corresponding strength, the lines of fracture from time to time caused in it, must have occurred at greater distances apart; the intermediate surfaces must have followed the contracting nucleus with less uniformity; and there must have resulted larger areas of land and water. If any one, after wrapping up an orange in tissue paper, and observing not only how small are the wrinkles, but how evenly the intervening spaces lie upon the surface of the orange, will then wrap it up in thick cartridge-paper, and note both the greater height of the ridges and the larger spaces throughout which the paper does not touch the orange, he will realize the fact that, as the Earth's solid envelope grew thicker, the areas of elevation and depression increased. In place of islands homogeneously dispersed amid an all-embracing sea, there must have gradually arisen heterogeneous arrangements of continent and ocean. Once more, this double change in the extent and in the elevation of the lands, involved yet another species of heterogeneity – that of coast-line. A tolerably even surface raised out of the ocean must have a simple, regular sea-margin; but a surface varied by table-lands and intersected by mountain-chains must, when raised out of the ocean, have an outline extremely irregular both in its leading features and in its details. Thus, multitudinous geological and geographical results are slowly brought about by this one cause – the contraction of the Earth.

When we pass from the agency termed igneous, to aqueous and atmospheric agencies, we see the like ever-growing complications of effects. The denuding actions of air and water, joined with those of changing temperature, have, from the beginning, been modifying every exposed surface. Oxidation, heat, wind, frost, rain, glaciers, rivers, tides, waves, have been unceasingly producing disintegration; varying in kind and amount according to local circumstances. Acting upon a tract of granite, they here work scarcely an appreciable effect; there cause exfoliations of the surface, and a resulting heap of *débris* and boulders; and elsewhere, after decomposing the feldspar into a white clay, carry away this and the accompanying quartz and mica, and deposit them in separate beds, fluviatile and marine. When the exposed land consists of several unlike kinds of sedimentary strata, or igneous rocks, or both, denudation produces changes proportionably more heterogeneous. The formations being disintegrable in different degrees, there follows an increased irregularity of surface. The areas drained by different rivers being differently constituted, these rivers carry down to the sea different combinations of ingredients; and so sundry new strata of unlike compositions are formed. And here we may see very simply illustrated, the truth, which we shall presently have to trace out in more involved cases, that in proportion to the heterogeneity of the object or objects on which any force expends itself, is the heterogeneity of the effects. A continent of complex structure, exposing many strata irregularly distributed, raised to various levels, tilted up at all angles, will, under the same denuding agencies, give origin to innumerable and involved results: each district must be differently modified; each river must carry down a different kind of detritus; each deposit must be differently distributed by the entangled currents, tidal and other, which wash the contorted shores; and this multiplication of results must manifestly be greatest where the complexity of surface is greatest.

Here we might show how the general truth, that every active force produces more than one change, is again exemplified in the highly-involved flow of the tides, in the ocean currents, in the winds, in the distribution of rain, in the distribution of heat, and so forth. But not to dwell upon these, let us, for the fuller elucidation of this truth in relation to the inorganic world, consider what would be the consequences of some extensive cosmical catastrophe – say the subsidence of Central America. The immediate results of the disturbance would themselves be sufficiently complex. Besides the numberless dislocations of strata, the ejections of igneous matter, the propagation of earthquake vibrations thousands of miles around, the loud explosions, and the escape of gases; there would be the rush of the Atlantic and Pacific Oceans to fill the vacant space, the subsequent recoil of enormous waves, which would traverse both these oceans and produce myriads of changes along their shores, the corresponding atmospheric waves complicated by the currents surrounding each volcanic vent, and the electrical discharges with which such disturbances are accompanied. But these temporary effects would be insignificant compared with the permanent ones. The currents of the Atlantic and Pacific would be altered in their directions and amounts. The distribution of heat achieved by those ocean currents would be different from what it is. The arrangement of the isothermal lines, not only on neighbouring continents, but even throughout Europe, would be changed. The tides would flow differently from what they do now. There would be more or less modification of the winds in their periods, strengths, directions, qualities. Rain would fall scarcely anywhere at the same times and in the same quantities as at present. In short, the meteorological conditions thousands of miles off, on all sides, would be more or less revolutionized. Thus, without taking into account the infinitude of modifications which these changes would produce upon the flora and fauna, both of land and sea, the reader will perceive the immense heterogeneity of the results wrought out by one force, when that force expends itself upon a previously complicated area; and he will draw the corollary that from the beginning the complication has advanced at an increasing rate.

Before going on to show how organic progress also depends on the law that every force produces more than one change, we have to notice the manifestation of this law in yet another species of inorganic progress – namely, chemical. The same general causes that have wrought out the heterogeneity of the Earth, physically considered, have simultaneously wrought out its chemical heterogeneity. There is every reason to believe that at an extreme heat the elements cannot combine. Even under such heat as can be artificially produced, some very strong affinities yield, as, for instance, that of oxygen for hydrogen; and the great majority of chemical compounds are decomposed at much lower temperatures. But without insisting on the highly probable inference, that when the Earth was in its first state of incandescence there were no chemical combinations at all, it will suffice for our purpose to point to the unquestionable fact that the compounds which can exist at the highest temperatures, and which must, therefore, have been the first that were formed as the Earth cooled, are those of the simplest constitutions. The protoxides – including under that head the alkalies, earths, &c. – are, as a class, the most stable compounds we know: most of them resisting decomposition by any heat we can generate. These are combinations of the simplest order – are but one degree less homogeneous than the elements themselves. More heterogeneous, less stable, and therefore later in the Earth's history, are the deutoxides, tritoxides, peroxides, &c.; in which two, three, four, or more atoms of oxygen are united with one atom of metal or other element. Higher than these in heterogeneity are the hydrates; in which an oxide of hydrogen, united with an oxide of some other element, forms a substance whose atoms severally contain at least four ultimate atoms of three different kinds. Yet more heterogeneous and less stable still are the salts; which present us with molecules each made up of five, six, seven, eight, ten, twelve, or more atoms, of three, if not more, kinds. Then there are the hydrated salts, of a yet greater heterogeneity, which undergo partial decomposition at much lower temperatures. After them come the further complicated supersalts and double salts, having a stability again decreased; and so throughout. Without entering into qualifications for which space fails, we believe no chemist will deny it to be a general law of these inorganic combinations that, *other things equal*, the stability decreases as the complexity increases. When we pass to the compounds of organic chemistry, we find this general law still further exemplified: we find much greater complexity and much less stability. A molecule of albumen, for instance, consists of 482 ultimate atoms of five different kinds. Fibrine, still more intricate in constitution, contains in each molecule, 298 atoms of carbon, 49 of nitrogen, 2 of sulphur, 228 of hydrogen, and 92 of oxygen – in all, 669 atoms; or, more strictly speaking, equivalents. And these two substances are so unstable as to decompose at quite ordinary temperatures; as that to which the outside of a joint of roast meat is exposed. Thus it is manifest that the present chemical heterogeneity of the Earth's surface has arisen by degrees, as the decrease of heat has permitted; and that it has shown itself in three forms – first, in the multiplication of chemical compounds; second, in the greater number of different elements contained in the more modern of these compounds; and third, in the higher and more varied multiples in which these more numerous elements combine.

To say that this advance in chemical heterogeneity is due to the one cause, diminution of the Earth's temperature, would be to say too much; for it is clear that aqueous and atmospheric agencies have been concerned; and further, that the affinities of the elements themselves are implied. The cause has all along been a composite one: the cooling of the Earth having been simply the most general of the concurrent causes, or assemblage of conditions. And here, indeed, it may be remarked that in the several classes of facts already dealt with (excepting, perhaps, the first), and still more in those with which we shall presently deal, the causes are more or less compound; as indeed are nearly all causes with which we are acquainted. Scarcely any change can rightly be ascribed to one agency alone, to the neglect of the permanent or temporary conditions under which only this agency produces the change. But as it does not materially affect our argument, we prefer, for simplicity's sake, to use throughout the popular mode of expression. Perhaps it will be further objected, that to assign loss of heat as the cause of any changes, is to attribute these changes not to a force, but to the absence of a force. And this is true. Strictly speaking, the changes should be attributed to those forces which come into action when the antagonist force is withdrawn. But though there is inaccuracy in saying that the freezing of water is due to the loss of its heat, no practical error arises from it; nor will a parallel laxity of expression vitiate our statements respecting the multiplication of effects. Indeed, the objection serves but to draw attention to the fact, that not only does the exertion of a force produce more than one change, but the withdrawal of a force produces more than one change.

Returning to the thread of our exposition, we have next to trace, throughout organic progress, this same all-pervading principle. And here, where the evolution of the homogeneous into the heterogeneous was first observed, the production of many effects by one cause is least easy to demonstrate. The development of a seed into a plant, or an ovum into an animal, is so gradual, while the forces which determine it are so involved, and at the same time so unobtrusive, that it is difficult to detect the multiplication of effects which is elsewhere so obvious. But, guided by indirect evidence, we may safely conclude that here too the law holds. Note, first, how numerous are the changes which any marked action works upon an adult organism – a human being, for instance. An alarming sound or sight, besides the impressions on the organs of sense and the nerves, may produce a start, a scream, a distortion of the face, a trembling consequent on general muscular relaxation, a burst of perspiration, a rush of blood to the brain, followed possibly by arrest of the heart's action and by syncope; and if the subject be feeble, an indisposition with its long train of complicated symptoms may set in. Similarly in cases of disease. A minute portion of the small-pox virus introduced into the system, will, in a severe case, cause, during the first stage, rigors, heat of skin, accelerated pulse, furred tongue, loss of appetite, thirst, epigastric uneasiness, vomiting, headache, pains in the back and limbs, muscular weakness, convulsions, delirium, &c.; in the second stage, cutaneous eruption, itching, tingling, sore throat, swelled fauces, salivation, cough, hoarseness, dyspnœa, &c.; and in the third stage, œdematous inflammations, pneumonia, pleurisy, diarrhœa, inflammation of the brain, ophthalmia, erysipelas, &c.: each of which enumerated symptoms is itself more or less complex. Medicines, special foods, better air, might in like manner be instanced as producing multiplied results. Now it needs only to consider that the many changes thus wrought by one force upon an adult organism, will be in part paralleled in an embryo organism, to understand how here also, the evolution of the homogeneous into the heterogeneous may be due to the production of many effects by one cause. The external heat, which, falling on a matter having special proclivities, determines the first complications of the germ, may, by acting on these, superinduce further complications; upon these still higher and more numerous ones; and so on continually: each organ as it is developed serving, by its actions and reactions on the rest, to initiate new complexities. The first pulsations of the fœtal heart must simultaneously aid the unfolding of every part. The growth of each tissue, by taking from the blood special proportions of elements, must modify the constitution of the blood; and so must modify the nutrition of all the other tissues. The heart's action, implying as it does a certain waste, necessitates an addition to the blood of effete matters, which must influence the rest of the system, and perhaps, as some think, cause the formation of excretory organs. The nervous connexions established among the viscera must further multiply their mutual influences; and so continually. Still stronger becomes the probability of this view when we call to mind the fact, that the same germ may be evolved into different forms according to circumstances. Thus, during its earlier stages, every embryo is sexless – becomes either male or female as the balance of forces acting on it determines. Again, it is a well-established fact that the larva of a working-bee will develop into a queen-bee, if before it is too late, its food be changed to that on which the larvæ of queen-bees are fed. All which instances suggest that the proximate cause of each advance in embryonic complication is the action of incident forces upon the complication previously existing. Indeed, we may find *a priori* reason to think that the evolution proceeds after this manner. For since no germ, animal or vegetal, contains the slightest rudiment or indication of the future organism – since the microscope has shown us that the first process set up in every fertilized germ, is a process of repeated spontaneous fissions ending in the production of a mass of cells, not one of which exhibits any special character; there seems no alternative but to suppose that the partial organization at any moment existing in a growing embryo, is transformed by the agencies acting upon it into the succeeding phase of organization, and this into the next, until, through ever-increasing complexities, the ultimate form is reached. Not indeed that we can thus really explain the production of any plant or animal. We are still in the dark respecting those mysterious properties in virtue of which the germ, when subject to fit influences, undergoes the special changes that begin the series of transformations. All we aim to show, is, that given a germ possessing those particular proclivities distinguishing the species to which it belongs, and the evolution of an organism from it, probably depends on that multiplication of effects which we have seen to be the cause of progress in general, so far as we have yet traced it.

When, leaving the development of single plants and animals, we pass to that of the Earth's flora and fauna, the course of our argument again becomes clear and simple. Though, as was admitted in the first part of this article, the fragmentary facts Paleontology has accumulated, do not clearly warrant us in saying that, in the lapse of geologic time, there have been evolved more heterogeneous organisms, and more heterogeneous assemblages of organisms, yet we shall now see that there *must* ever have been a tendency towards these results. We shall find that the production of many effects by one cause, which as already shown, has been all along increasing the physical heterogeneity of the Earth, has further involved an increasing heterogeneity in its flora and fauna, individually and collectively. An illustration will make this clear. Suppose that by a series of upheavals, occurring, as they are now known to do, at long intervals, the East Indian Archipelago were to be, step by step, raised into a continent, and a chain of mountains formed along the axis of elevation. By the first of these upheavals, the plants and animals inhabiting Borneo, Sumatra, New Guinea, and the rest, would be subjected to slightly modified sets of conditions. The climate in general would be altered in temperature, in humidity, and in its periodical variations; while the local differences would be multiplied. These modifications would affect, perhaps inappreciably, the entire flora and fauna of the region. The change of level would produce additional modifications: varying in different species, and also in different members of the same species, according to their distance from the axis of elevation. Plants, growing only on the sea-shore in special localities, might become extinct. Others, living only in swamps of a certain humidity, would, if they survived at all, probably undergo visible changes of appearance. While still greater alterations would occur in the plants gradually spreading over the lands newly raised above the sea. The animals and insects living on these modified plants, would themselves be in some degree modified by change of food, as well as by change of climate; and the modification would be more marked where, from the dwindling or disappearance of one kind of plant, an allied kind was eaten. In the lapse of the many generations arising before the next upheaval, the sensible or insensible alterations thus produced in each species would become organized – there would be a more or less complete adaptation to the new conditions. The next upheaval would superinduce further organic changes, implying wider divergences from the primary forms; and so repeatedly. But now let it be observed that the revolution thus resulting would not be a substitution of a thousand more or less modified species for the thousand original species; but in place of the thousand original species there would arise several thousand species, or varieties, or changed forms. Each species being distributed over an area of some extent, and tending continually to colonize the new area exposed, its different members would be subject to different sets of changes. Plants and animals spreading towards the equator would not be affected in the same way as others spreading from it. Those spreading towards the new shores would undergo changes unlike the changes undergone by those spreading into the mountains. Thus, each original race of organisms, would become the root from which diverged several races differing more or less from it and from each other; and while some of these might subsequently disappear, probably more than one would survive in the next geologic period: the very dispersion itself increasing the chances of survival. Not only would there be certain modifications thus caused by change of physical conditions and food, but also in some cases other modifications caused by change of habit. The fauna of each island, peopling, step by step, the newly-raised tracts, would eventually come in contact with the faunas of other islands; and some members of these other faunas would be unlike any creatures before seen. Herbivores meeting with new beasts of prey, would, in some cases, be led into modes of defence or escape differing from those previously used; and simultaneously the beasts of prey would modify their modes of pursuit and attack. We know that when circumstances demand it, such changes of habit *do* take place in animals; and we know that if the new habits become the dominant ones, they must eventually in some degree alter the organization. Observe now, however, a further consequence. There must arise not simply a tendency towards the differentiation of each race of organisms into several races; but also a tendency to the occasional production of a somewhat higher organism. Taken in the mass these divergent varieties which have been caused by fresh physical conditions and habits of life, will exhibit changes quite indefinite in kind and degree; and changes that do not necessarily constitute an advance. Probably in most cases the modified type will be neither more nor less heterogeneous than the original one. In some cases the habits of life adopted being simpler than before, a less heterogeneous structure will result: there will be a retrogradation. But it *must* now and then occur, that some division of a species, falling into circumstances which give it rather more complex experiences, and demand actions somewhat more involved, will have certain of its organs further differentiated in proportionately small degrees, – will become slightly more heterogeneous. Thus, in the natural course of things, there will from time to time arise an increased heterogeneity both of the Earth's flora and fauna, and of individual races included in them. Omitting detailed explanations, and allowing for the qualifications which cannot here be specified, we think it is clear that geological mutations have all along tended to complicate the forms of life, whether regarded separately or collectively. The same causes which have led to the evolution of the Earth's crust from the simple into the complex, have simultaneously led to a parallel evolution of the Life upon its surface. In this case, as in previous ones, we see that the transformation of the homogeneous into the heterogeneous is consequent upon the universal principle, that every active force produces more than one change.

The deduction here drawn from the established truths of geology and the general laws of life, gains immensely in weight on finding it to be in harmony with an induction drawn from direct experience. Just that divergence of many races from one race, which we inferred must have been continually occurring during geologic time, we know to have occurred during the pre-historic and historic periods, in man and domestic animals. And just that multiplication of effects which we concluded must have produced the first, we see has produced the last. Single causes, as famine, pressure of population, war, have periodically led to further dispersions of mankind and of dependent creatures: each such dispersion initiating new modifications, new varieties of type. Whether all the human races be or be not derived from one stock, philology makes it clear that whole groups of races now easily distinguishable from each other, were originally one race, – that the diffusion of one race into different climates and conditions of existence, has produced many modified forms of it. Similarly with domestic animals. Though in some cases – as that of dogs – community of origin will perhaps be disputed, yet in other cases – as that of the sheep or the cattle of our own country – it will not be questioned that local differences of climate, food, and treatment, have transformed one original breed into numerous breeds now become so far distinct as to produce unstable hybrids. Moreover, through the complication of effects flowing from single causes, we here find, what we before inferred, not only an increase of general heterogeneity, but also of special heterogeneity. While of the divergent divisions and subdivisions of the human race many have undergone changes not constituting an advance; while in some the type may have degraded; in others it has become decidedly more heterogeneous. The civilized European departs more widely from the vertebrate archetype than does the savage. Thus, both the law and the cause of progress, which, from lack of evidence, can be but hypothetically substantiated in respect of the earlier forms of life on our globe, can be actually substantiated in respect of the latest forms.[4]

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[4] The argument concerning organic evolution contained in this paragraph and the one preceding it, stands verbatim as it did when first published in the *Westminster Review* for April, 1857. I have thus left it without the alteration of a word that it may show the view I then held concerning the origin of species. The sole cause recognized is

If the advance of Man towards greater heterogeneity is traceable to the production of many effects by one cause, still more clearly may the advance of Society towards greater heterogeneity be so explained. Consider the growth of an industrial organization. When, as must occasionally happen, some member of a tribe displays unusual aptitude for making an article of general use – a weapon, for instance – which was before made by each man for himself, there arises a tendency towards the differentiation of that member into a maker of such weapon. His companions – warriors and hunters all of them, – severally feel the importance of having the best weapons that can be made; and are therefore certain to offer strong inducements to this skilled individual to make weapons for them. He, on the other hand, having not only an unusual faculty, but an unusual liking, for making such weapons (the talent and the desire for any occupation being commonly associated), is predisposed to fulfil each commission on the offer of an adequate reward: especially

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that of direct adaptation of constitution to conditions consequent on inheritance of the modifications of structure resulting from use and disuse. There is no recognition of that further cause disclosed in Mr. Darwin's work, published two and a half years later – the indirect adaptation resulting from the natural selection of favourable variations. The multiplication of effects is, however, equally illustrated in whatever way the adaptation to changing conditions is effected, or if it is effected in both ways, as I hold. I may add that there is indicated the view that the succession of organic forms is not serial but proceeds by perpetual divergence and re-divergence – that there has been a continual "divergence of many races from one race": each species being a "root" from which several other species branch out; and the growth of a tree being thus the implied symbol.

as his love of distinction is also gratified and his living facilitated. This first specialization of function, once commenced, tends ever to become more decided. On the side of the weapon-maker practice gives increased skill – increased superiority to his products. On the side of his clients, cessation of practice entails decreased skill. Thus the influences which determine this division of labour grow stronger in both ways; and the incipient heterogeneity is, on the average of cases, likely to become permanent for that generation if no longer. This process not only differentiates the social mass into two parts, the one monopolizing, or almost monopolizing, the performance of a certain function, and the other losing the habit, and in some measure the power, of performing that function; but it tends to initiate other differentiations. The advance described implies the introduction of barter, – the maker of weapons has, on each occasion, to be paid in such other articles as he agrees to take in exchange. He will not habitually take in exchange one kind of article, but many kinds. He does not want mats only, or skins, or fishing-gear, but he wants all these, and on each occasion will bargain for the particular things he most needs. What follows? If among his fellows there exist any slight differences of skill in the manufacture of these various things, as there are almost sure to do, the weapon-maker will take from each one the thing which that one excels in making: he will exchange for mats with him whose mats are superior, and will bargain for the fishing-gear of him who has the best. But he who has bartered away his mats or his fishing-gear, must make other mats or fishing-gear for himself; and in so doing must, in some degree, further develop his aptitude. Thus it results that the small specialities of faculty possessed by various members of the tribe, will tend to grow more decided. And whether or not there ensue distinct differentiations of other individuals into makers of particular articles, it is clear that incipient differentiations take place throughout the tribe: the one original cause produces not only the first dual effect, but a number of secondary dual effects, like in kind, but minor in degree. This process, of which traces may be seen among schoolboys, cannot well produce lasting effects in an unsettled tribe; but where there grows up a fixed and multiplying community, such differentiations become permanent, and increase with each generation. The enhanced demand for every commodity, intensifies the functional activity of each specialized person or class; and this renders the specialization more definite where it already exists, and establishes it where it is but nascent. By increasing the pressure on the means of subsistence, a larger population again augments these results; seeing that each person is forced more and more to confine himself to that which he can do best, and by which he can gain most. Presently, under these same stimuli, new occupations arise. Competing workers, ever aiming to produce improved articles, occasionally discover better processes or raw materials. The substitution of bronze for stone entails on him who first makes it a great increase of demand;

so that he or his successor eventually finds all his time occupied in making the bronze for the articles he sells, and is obliged to depute the fashioning of these articles to others; and, eventually, the making of bronze, thus differentiated from a pre-existing occupation, becomes an occupation by itself. But now mark the ramified changes which follow this change. Bronze presently replaces stone, not only in the articles it was first used for, but in many others – in arms, tools, and utensils of various kinds: and so affects the manufacture of them. Further, it affects the processes which these utensils subserve, and the resulting products, – modifies buildings, carvings, personal decorations. Yet again, it sets going manufactures which were before impossible, from lack of a material fit for the requisite implements. And all these changes react on the people – increase their manipulative skill, their intelligence, their comfort, – refine their habits and tastes. Thus the evolution of a homogeneous society into a heterogeneous one, is clearly consequent on the general principle, that many effects are produced by one cause.

Space permitting, we might show how the localization o£ special industries in special parts of a kingdom, as well as the minute subdivision of labour in the making of each commodity, are similarly determined. Or, turning to a somewhat different order of illustrations, we might dwell on the multitudinous changes – material, intellectual, moral, – caused by printing; or the further extensive series of changes wrought by gunpowder. But leaving the intermediate phases of social development, let us take a few illustrations from its most recent and its passing phases. To trace the effects of steam-power, in its manifold applications to mining, navigation, and manufactures of all kinds, would carry us into unmanageable detail. Let us confine ourselves to the latest embodiment of steam power – the locomotive engine. This, as the proximate cause of our railway system, has changed the face of the country, the course of trade, and the habits of the people. Consider, first, the complicated sets of changes that precede the making of every railway – the provisional arrangements, the meetings, the registration, the trial section, the parliamentary survey, the lithographed plans, the books of reference, the local deposits and notices, the application to Parliament, the passing Standing Orders Committee, the first, second, and third readings: each of which brief heads indicates a multiplicity of transactions, and the extra development of sundry occupations – as those of engineers, surveyors, lithographers, parliamentary agents, share-brokers; and the creation of sundry others – as those of traffic-takers, reference-takers. Consider, next, the yet more marked changes implied in railway construction – the cuttings, embankings, tunnellings, diversions of roads; the building of bridges and stations, the laying down of ballast, sleepers, and rails; the making of engines, tenders, carriages, and waggons: which processes, acting on numerous trades, increase the importation of timber, the quarrying of stone, the manufacture of iron, the mining of coal, the burning of bricks; institute a variety of special manufactures weekly advertised in the *Railway Times*; and, finally, open the way to sundry new occupations, as those of drivers, stokers, cleaners, plate-layers, &c., &c. And then consider the changes, still more numerous and involved, which railways in action produce on the community at large. Business agencies are established where previously they would not have paid; goods are obtained from remote wholesale houses instead of near retail ones; and commodities are used which distance once rendered inaccessible. Again, the diminished cost of carriage tends to specialize more than ever the industries of different districts – to confine each manufacture to the parts in which, from local advantages, it can be best carried on. Further, the fall in freights, facilitating distribution, equalizes prices, and also, on the average, lowers prices: thus bringing divers articles within the means of those before unable to buy them, and so increasing their comforts and improving their habits. At the same time the practice of travelling is immensely extended. People who never before dreamed of it, take trips to the sea; visit their distant relations; make tours; and so we are benefited in body, feelings, and ideas. The more prompt transmission of letters and of news produces other marked changes – makes the pulse of the nation faster. Once more, there arises a wide dissemination of cheap literature through railway book-stalls, and of advertisements in railway carriages: both of them aiding ulterior progress. And the countless changes here briefly indicated are consequent on the invention of the locomotive engine. The social organism has been rendered more heterogeneous in virtue of the many new occupations introduced, and the many old ones further specialized; prices of nearly all things in every place have been altered; each trader has modified his way of doing business; and every person has been affected in his actions, thoughts, emotions.

Illustrations to the same effect might be indefinitely accumulated, but they are needless. The only further fact demanding notice, is, that we here see still more clearly the truth before pointed out, that in proportion as the area on which any force expends itself becomes heterogeneous, the results are in a yet higher degree multiplied in number and kind. While among the simple tribes to whom it was first known, caoutchouc caused but few changes, among ourselves the changes have been so many and varied that the history of them occupies a volume.[5] Upon the small, homogeneous community inhabiting one of the Hebrides, the electric telegraph would produce, were it used, scarcely any results; but in England the results it produces are multitudinous. The comparatively simple organization under which our ancestors lived five centuries ago, could have undergone but few modifications from an event like the recent one at Canton; but now, the legislative decision respecting it sets up many hundreds of complex modifications, each of which will be the parent of numerous future ones.

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[5] "Personal Narrative of the Origin of the Caoutchouc, or India-Rubber Manufacture in England." By Thomas Hancock.

Space permitting, we could willingly have pursued the argument in relation to all the subtler results of civilization. As before we showed that the law of progress to which the organic and inorganic worlds conform, is also conformed to by Language, the plastic arts, Music, &c.; so might we here show that the cause which we have hitherto found to determine progress holds in these cases also. Instances might be given proving how, in Science, an advance of one division presently advances other divisions – how Astronomy has been immensely forwarded by discoveries in Optics, while other optical discoveries have initiated Microscopic Anatomy, and greatly aided the growth of Physiology – how Chemistry has indirectly increased our knowledge of Electricity, Magnetism, Biology, Geology – how Electricity has reacted on Chemistry and Magnetism, and has developed our views of Light and Heat. In Literature the same truth might be exhibited in the manifold effects of the primitive mystery-play, as originating the modern drama, which has variously branched; or in the still multiplying forms of periodical literature which have descended from the first newspaper, and which have severally acted and reacted on other forms of literature and on each other. The influence which a new school of Painting – as that of the pre-Raphaelites – exercises upon other schools; the hints which all kinds of pictorial art are deriving from Photography; the complex results of new critical doctrines, as those of Mr. Ruskin, might severally be dwelt upon as displaying the like multiplication of effects.

But we venture to think our case is already made out. The imperfections of statement which brevity has necessitated, do not, we believe, invalidate the propositions laid down. The qualifications here and there demanded would not, if made, affect the inferences. Though, in tracing the genesis of progress, we have frequently spoken of complex causes as if they were simple ones; it still remains true that such causes are far less complex than their results. Detailed criticisms do not affect our main position. Endless facts go to show that every kind of progress is from the homogeneous to the heterogeneous; and that it is so because each change is followed by many changes. And it is significant that where the facts are most accessible and abundant, there these truths are most manifest.

However, to avoid committing ourselves to more than is yet proved, we must be content with saying that such are the law and the cause of all progress that is known to us. Should the Nebular Hypothesis ever be established, then it will become manifest that the Universe at large, like every organism, was once homogeneous; that as a whole, and in every detail, it has unceasingly advanced towards greater heterogeneity. It will be seen that as in each event of to-day, so from the beginning, the decomposition of every expended force into several forces has been perpetually producing a higher complication; that the increase of heterogeneity so brought about is still going on and must continue to go on; and that thus progress is not an accident, not a thing within human control, but a beneficent necessity.

A few words must be added on the ontological bearings of our argument. Probably not a few will conclude that here is an attempted solution of the great questions with which Philosophy in all ages has perplexed itself. Let none thus deceive themselves. After all that has been said, the ultimate mystery remains just as it was. The explanation of that which is explicable, does but bring out into greater clearness the inexplicableness of that which remains behind. Little as it seems to do so, fearless inquiry tends continually to give a firmer basis to all true Religion. The timid sectarian, obliged to abandon one by one the superstitions bequeathed to him, and daily finding his cherished beliefs more and more shaken, secretly fears that all things may some day be explained; and has a corresponding dread of Science: thus evincing the profoundest of all infidelity – the fear lest the truth be bad. On the other hand, the sincere man of science, content to follow wherever the evidence leads him, becomes by each new inquiry more profoundly convinced that the Universe is an insoluble problem. Alike in the external and the internal worlds, he sees himself in the midst of ceaseless changes, of which he can discover neither beginning nor end. If, tracing back the evolution of things, he allows himself to entertain the hypothesis that all matter once existed in a diffused form, he finds it impossible to conceive how this came to be so; and equally, if he speculates on the future, he can assign no limit to the grand succession of phenomena ever unfolding themselves before him. Similarly, if he looks inward, he perceives that both terminations of the thread of consciousness are beyond his grasp: he cannot remember when or how consciousness commenced, and he cannot examine the consciousness at any moment existing; for only a state of consciousness which is already past can become the object of thought, and never one which is passing. When, again, he turns from the succession of phenomena, external or internal, to their essential nature, he is equally at fault. Though he may succeed in resolving all properties of objects into manifestations of force, he is not thereby enabled to conceive what force is; but finds, on the contrary, that the more he thinks about it, the more he is baffled. Similarly, though analysis of mental actions may finally bring him down to sensations as the original materials out of which all thought is woven, he is none the forwarder; for he cannot in the least comprehend sensation. Inward and outward things he thus discovers to be alike inscrutable in their ultimate genesis and nature. He sees that the Materialist and Spiritualist controversy is a mere war of words; the disputants being equally absurd – each believing he understands that which it is impossible for any man to understand. In all directions his investigations eventually bring him face to face with the unknowable; and he ever more clearly perceives it to be the unknowable. He learns at once the greatness and the littleness of human intellect – its power in dealing with all that comes within the range of experience; its impotence in dealing with all that transcends experience. He feels more vividly than any others can feel, the utter incomprehensibleness of the simplest fact, considered in itself. He alone truly *sees* that absolute knowledge is impossible. He alone *knows* that under all things there lies an impenetrable mystery.

TRANSCENDENTAL PHYSIOLOGY

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The title Transcendental Anatomy is used to distinguish that division of biological science which treats, not of the structures of individual organisms considered separately, but of the general principles of structure common to vast and varied groups of organisms, – the unity of plan discernible throughout multitudinous species, genera, and orders, which differ widely in appearance. And here, under the head of Transcendental Physiology, we purpose putting together sundry laws of development and function which hold not of particular kinds or classes of organisms, but of all organisms: laws, some of which have not, we believe, been hitherto enunciated.

By way of unobtrusively introducing the general reader to biological truths of this class, let us begin by noticing one or two with which he is familiar. Take first, the relation between the activity of an organ and its growth. This is a universal relation. It holds, not only of a bone, a muscle, a nerve, an organ of sense, a mental faculty; but of every gland, every viscus, every element of the body. It is seen, not in man only, but in each animal which affords us adequate opportunity of tracing it. Always providing that the performance of function is not so excessive as to produce disorder, or to exceed the repairing powers either of the system at large or of the particular agencies by which nutriment is brought to the organ, – always providing this, it is a law of organized bodies that, other things equal, development varies as function. On this law are based all maxims and methods of right education, intellectual, moral, and physical; and when statesmen are wise enough to see it, this law will be found to underlie all right legislation.

Another truth co-extensive with the organic world, is that of hereditary transmission. It is not, as commonly supposed, that hereditary transmission is exemplified merely in re-appearance of the family peculiarities displayed by immediate or remote progenitors. Nor does the law of hereditary transmission comprehend only such more general facts as that modified plants or animals become the parents of permanent varieties; and that new kinds of potatoes, new breeds of sheep, new races of men, have been thus originated. These are but minor exemplifications of the law. Understood in its entirety, the law is that each plant or animal produces others of like kind with itself: the likeness of kind consisting not so much in the repetition of individual traits as in the assumption of the same general structure. This truth has been made by daily illustration so familiar as nearly to have lost its significance. That wheat produces wheat, – that existing oxen are descended from ancestral oxen, – that every unfolding organism ultimately takes the form of the class, order, genus, and species from which it sprang; is a fact which, by force of repetition, has assumed in our minds the character of a necessity. It is in this, however, that the law of hereditary transmission is principally displayed; the phenomena commonly named as exemplifying it being quite subordinate manifestations. And the law, as thus understood, is universal. Not forgetting the apparent, but only apparent, exceptions presented by the strange class of phenomena known as "alternate generation," the truth that like produces like is common to all types of organisms.

Let us take next a universal physiological law of a less conspicuous kind. To the ordinary observer, it seems that the multiplication of organisms proceeds in various ways. He sees that the young of the higher animals when born resemble their parents; that birds lay eggs, which they foster and hatch; that fish deposit spawn and leave it. Among plants, he finds that while in some cases new individuals grow from seeds only, in other cases they also grow from tubers; that by certain plants layers are sent out, take root, and develop new individuals; and that many plants can be reproduced from cuttings. Further, in the mould that quickly covers stale food, and the infusoria that soon swarm in water exposed to air and light, he sees a mode of generation which, seeming inexplicable, he is apt to consider "spontaneous." The reader of popular science thinks the modes of reproduction still more various. He learns that whole tribes of creatures multiply by gemmation – by a development from the body of the parent of buds which, after unfolding into the parental form, separate and lead independent lives. Concerning microscopic forms of both animal and vegetal life, he reads that the ordinary mode of multiplication is by spontaneous fission – a splitting up of the original individual into two or more individuals, which by and by severally repeat the process. Still more remarkable are the cases in which, as in the *Aphis*, an egg gives rise to an imperfect female, from which other imperfect females are born viviparously, grow, and in their turns bear other imperfect females; and so on for eight, ten, or more generations, until finally, perfect males and females are viviparously produced. But now under all these, and many more, modified modes of multiplication, the physiologist finds complete uniformity. The starting-point, not only of every higher animal or plant, but of every clan of organisms which by fission or gemmation have sprung from a single organism, is always a spore, seed, or ovum. The millions of infusoria or of aphides which, by sub-division or gemmation, have proceeded from one individual; the countless plants which have been successively propagated from one original plant by cuttings or tubers; are, in common with the highest creature, primarily descended from a fertilized germ. And in all cases – in the humblest alga as in the oak, in the protozoon as in the mammal – this fertilized germ results from the union of the contents of two cells. Whether, as among the lowest forms of life, these two cells are seemingly identical in nature; or whether, as among higher forms, they are distinguishable into sperm-cell and germ-cell; it remains throughout true that from their combination results the mass out of which is evolved a new organism or new series of organisms. That this law is without exception we are not prepared to say; for in the case of the *Aphis* certain experiments are thought to imply that under special conditions the descendants of an original individual may continue multiplying for ever, without further fecundation. But we know of no case where it *actually is* so; for although there are certain plants of which the seeds have never been seen, it is more probable that our observations are in fault than that these plants are exceptions. And until we find undoubted exceptions, the above-stated induction must stand. Here, then, we have another of the truths of Transcendental Physiology: a truth which, so far as we know, *transcends* all distinctions of genus, order, class, kingdom, and applies to every living thing.

Yet another generalization of like universality expresses the process of organic development. To the ordinary observer there seems no unity in this. No obvious parallelism exists between the unfolding of a plant and the unfolding of an animal. There is no manifest similarity between the development of a mammal, which proceeds without break from its first to its last stage, and that of an insect, which is divided into strongly-marked stages – egg, larva, pupa, imago. Nevertheless it is now an established fact, that all organisms are evolved after one general method. At the outset the germ of every plant or animal is relatively homogeneous; and advance towards maturity is advance towards greater heterogeneity. Each organized thing commences as an almost structureless mass, and reaches its ultimate complexity by the establishment of distinctions upon distinctions, – by the divergence of tissues from tissues and organs from organs. Here, then, we have yet another biological law of transcendent generality.

Having thus recognized the scope of Transcendental Physiology as presented in its leading truths, we are prepared for the considerations that are to follow.

And first, returning to the last of the great generalizations above given, let us inquire more nearly how this change from the homogeneous to the heterogeneous is carried on. Usually it is said to result from successive differentiations. This, however, cannot be considered a complete account of the process. During the evolution of an organism there occur, not only separations of parts, but coalescences of parts. There is not only segregation, but aggregation. The heart, at first a simple pulsating blood-vessel, by and by twists upon itself and becomes integrated. The bile-cells constituting the rudimentary liver, do not merely diverge from the surface of the intestine in which they at first form a simple layer; but they simultaneously consolidate into a definite organ. And the gradual concentration seen in these and other cases is a part of the developmental process – a part which, though more or less recognized by Milne-Edwards and others, does not seem to have been included as an essential element in it.

This progressive integration, manifest alike when tracing up the several stages passed through by every embryo, and when ascending from the lower organic forms to the higher, may be most conveniently studied under several heads. Let us consider first what may be called *longitudinal integration*.

The lower *Annulosa*– worms, myriapods, &c. – are characterized by the great numbers of segments of which they respectively consist, reaching in some cases to several hundreds; but as we advance to the higher *Annulosa*– centipedes, crustaceans, insects, spiders, – we find these numbers greatly reduced, down to twenty-two, thirteen, and even fewer; and accompanying this there is a shortening or integration of the whole body, reaching its extreme in crabs and spiders. Similarly with the development of an individual crustacean or insect. The thorax of a lobster, which, in the adult, forms, with the head, one compact box containing the viscera, is made up by the union of a number of segments which in the embryo were separable. The thirteen distinct divisions seen in the body of a caterpillar, become further integrated in the butterfly: several segments are consolidated to form the thorax, and the abdominal segments are more aggregated than they originally were. The like truth is seen when we pass to the internal organs. In the lower annulose forms, and in the larvæ of the higher ones, the alimentary canal consists either of a tube that is uniform from end to end, or else bulges into a succession of stomachs, one to each segment; but in the developed forms there is a single well-defined stomach. In the nervous, vascular, and respiratory systems a parallel concentration may be traced. Again, in the development of the *Vertebrata* we have sundry examples of longitudinal integration. The coalescence of several segmental groups of bones to form the skull is one instance of it. It is further illustrated in the *os coccygis*, which results from the fusion of a number of caudal vertebræ. And in the consolidation of the sacral vertebræ of a bird it is also well exemplified.

That which we may distinguish as *transverse integration*, is well illustrated among the *Annulosa* in the development of the nervous system. Leaving out those simple forms which do not present distinct ganglia, it is to be observed that the lower annulose animals, in common with the larvæ of the higher, are severally characterized by a double chain of ganglia running from end to end of the body; while in the more advanced annulose animals this double chain becomes a single chain. Mr. Newport has described the course of this concentration in insects; and by Rathke it has been traced in crustaceans. In the early stages of the *Astacus fluviatilis*, or common cray-fish, there is a pair of separate ganglia to each ring. Of the fourteen pairs belonging to the head and thorax, the three pairs in advance of the mouth consolidate into one mass to form the brain, or cephalic ganglion. Meanwhile out of the remainder, the first six pairs severally unite in the median line, while the rest remain more or less separate. Of these six double ganglia thus formed, the anterior four coalesce into one mass; the remaining two coalesce into another mass; and then these two masses coalesce into one. Here we see longitudinal and transverse integration going on simultaneously; and in the highest crustaceans they are both carried still further. The *Vertebrata* exhibit this transverse integration in the development of the generative system. The lowest of the mammalia – the *Monotremata*– in common with birds, have oviducts which towards their lower extremities are dilated into cavities severally performing in an imperfect way the function of a uterus. "In the *Marsupialia*, there is a closer approximation of the two lateral sets of organs on the median line; for the oviducts converge towards one another and meet (without coalescing) on the median line; so that their uterine dilatations are in contact with each other, forming a true 'double uterus.' … As we ascend the series of 'placental' mammals, we find the lateral coalescence becoming gradually more and more complete… In many of the *Rodentia*, the uterus still remains completely divided into two lateral halves; whilst in others, these coalesce at their lower portion, forming a rudiment of the true 'body' of the uterus in the Human subject. This part increases at the expense of the lateral 'cornua' in the higher Herbivora and Carnivora; but even in the lower Quadrumana, the uterus is somewhat cleft at its summit."[6] And this process of transverse integration, which is still more striking when observed in its details, is accompanied by parallel though less important changes in the opposite sex. Once more; in the increasing commissural

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[6] Carpenter's *Principles of Comparative Physiology*, pp. 616-17.

connexion of the cerebral hemispheres, which, though separate in the lower vertebrata, become gradually more united in the higher, we have another instance. And further ones of a different order, but of like general implication, are supplied by the vascular system.

Now it seems to us that the various kinds of integration here exemplified, which are commonly set down as so many independent phenomena, ought to be generalized, and included in the formula describing the process of development. The fact that in an adult crab, many pairs of ganglia originally separate have become fused into a single mass, is a fact only second in significance to the differentiation of its alimentary canal into stomach and intestine. That in the higher *Annulosa*, a single heart replaces the string of rudimentary hearts constituting the dorsal blood-vessel in the lower *Annulosa*, (reaching in one species to the number of one hundred and sixty), is a truth as much needing to be comprised in the history of evolution, as is the formation of a respiratory surface by a branched expansion of the skin. A right conception of the genesis of a vertebral column, includes not only the differentiations from which result the *chorda dorsalis* and the vertebral segments imbedded in it; but quite as much it includes the coalescence of numerous vertebral processes with their respective vertebral bodies. The changes in virtue of which several things become one, demand recognition equally with those in virtue of which one thing becomes several. Evidently, then, the current statement which ascribes the developmental progress to differentiations alone, is incomplete. Adequately to express the facts, we must say that the transition from the homogeneous to the heterogeneous is carried on by differentiations and accompanying integrations.

It may not be amiss here to ask – What is the meaning of these integrations? The evidence seems to show that they are in some way dependent on community of function. The eight segments which coalesce to make the head of a centipede, jointly protect the cephalic ganglion, and afford a solid fulcrum for the jaws, &c. The many bones which unite to form a vertebral skull have like uses. In the consolidation of the several pieces which constitute a mammalian pelvis, and in the anchylosis of from ten to nineteen vertebræ in the sacrum of a bird, we have kindred instances of the integration of parts which transfer the weight of the body to the legs. The more or less extensive fusion of the tibia with the fibula and the radius with the ulna in the ungulated mammals, whose habits require only partial rotations of the limbs, is a fact of like meaning. And all the instances lately given – the concentration of ganglia, the replacement of many pulsating blood-sacs by fewer and finally by one, the fusion of two uteri into a single uterus – have the same implication. Whether, as in some cases, the integration is merely a consequence of the growth which eventually brings into contact adjacent parts performing similar duties; or whether, as in other cases, there is an actual approximation of these parts before their union; or whether, as in yet other cases, the integration is of that indirect kind which arises when, out of a number of like organs, one, or a group, discharges an ever-increasing share of the common function, and so grows while the rest dwindle and disappear; – the general fact remains the same, that there is a tendency to the unification of parts having similar duties.

The tendency, however, acts under limiting conditions; and recognition of them will explain some apparent exceptions. In the human fœtus, as in the lower vertebrata, the eyes are placed one on each side of the head. During evolution they become relatively nearer, and at birth are in front; though they are still, in the European infant as in the adult Mongol, proportionately further apart than they afterwards become. But this approximation shows no signs of further increase. Two reasons suggest themselves. One is that the two eyes have not quite the same function, since they are directed to slightly-different aspects of each object looked at; and, since the resulting binocular vision has an advantage over monocular vision, there results a check upon further approach towards identity of function and unity of structure. The other reason is that the interposed structures do not admit of any nearer approach. For the orbits of the eyes to be brought closer together, would imply a decrease in the olfactory chambers; and as these are probably not larger than is demanded by their present functional activity, no decrease can take place. Again, if we trace up the external organs of smell through fishes,[7] reptiles, ungulate mammals and

[7] With the exception, perhaps, of the Myxinoid fishes, in which what is considered

unguiculate mammals, to man, we perceive a general tendency to coalescence in the median line; and on comparing the savage with the civilized, or the infant with the adult, we see this approach of the nostrils carried furthest in the most perfect of the species. But since the septum which divides them has the function both of an evaporating surface for the lachrymal secretion, and of a ramifying surface for a nerve ancillary to that of smell, it does not disappear entirely: the integration remains incomplete. These and other like instances do not however militate against the hypothesis. They merely show that the tendency is sometimes antagonized by other tendencies. Bearing in mind which qualification, we may say, that as differentiation of parts is connected with difference of function, so there appears to be a connexion between integration of parts and sameness of function.

Closely related to the general truth that the evolution of all organisms is carried on by combined differentiations and integrations, is another general truth, which physiologists appear not to have recognized. When we look at the organic world as a whole, we may observe that, on passing from lower to higher forms, we pass to forms which are not only characterized by a greater differentiation of parts, but are at the same time more completely differentiated from the surrounding medium. This

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as the nasal orifice is single, and on the median line. But seeing how unusual is the position of this orifice, it seems questionable whether it is the true homologue of the nostrils.

truth may be contemplated under various aspects.

In the first place it is illustrated in *structure*. The advance from the homogeneous to the heterogeneous itself involves an increasing distinction from the inorganic world. In the lowest *Protozoa*, as some of the Rhizopods, we have a homogeneity approaching to that of air, water, or earth; and the ascent to organisms of greater and greater complexity of structure, is an ascent to organisms which are in that respect more strongly contrasted with the relatively structureless masses in the environment.

In *form* again we see the same truth. A general characteristic of inorganic matter is its indefiniteness of form, and this is also a characteristic of the lower organisms, as compared with the higher. Speaking generally, plants are less definite than animals, both in shape and size – admit of greater modifications from variations of position and nutrition. Among animals, the *Amœba* and its allies are not only almost structureless, but are amorphous; and the irregular form is constantly changing. Of the organisms resulting from the aggregation of amœba-like creatures, we find that while some assume a certain definiteness of form, in their compound shells at least, others, as the Sponges, are irregular. In the Zoophytes and in the *Polyzoa*, we see compound organisms, most of which have modes of growth not more determinate than those of plants. But among the higher animals, we find not only that the mature shape of each species is quite definite, but that the individuals of each species differ very little in size.

A parallel increase of contrast is seen in *chemical composition*. With but few exceptions, and those only partial ones, the lowest animal and vegetal forms are inhabitants of the water; and water is almost their sole constituent. Dessicated *Protophyta* and *Protozoa* shrink into mere dust; and among the acalephes we find but a few grains of solid matter to a pound of water. The higher aquatic plants, in common with the higher aquatic animals, possessing as they do much greater tenacity of substance, also contain a greater proportion of the organic elements; and so are chemically more unlike their medium. And when we pass to the superior classes of organisms – land plants and land animals – we find that, chemically considered, they have little in common either with the earth on which they stand or the air which surrounds them.

In *specific gravity*, too, we may note the like. The very simplest forms, in common with the spores and gemmules of the higher ones, are as nearly as may be of the same specific gravity as the water in which they float; and though it cannot be said that among aquatic creatures superior specific gravity is a standard of general superiority, yet we may fairly say that the superior orders of them, when divested of the appliances by which their specific gravity is regulated, differ more from water in their relative weights than do the lower. In terrestrial organisms, the contrast becomes extremely marked. Trees and plants, in common with insects, reptiles, mammals, birds, are all of a specific gravity considerably less than the earth and immensely greater than the air.

We see the law similarly fulfilled in respect of *temperature*. Plants generate but an extremely small quantity of heat, which is to be detected only by delicate experiments; and practically they may be considered as being in this respect like their environment. Aquatic animals rise very little above the surrounding water in temperature: that of the invertebrata being mostly less than a degree above it, and that of fishes not exceeding it by more than two or three degrees, save in the case of some large red-blooded fishes, as the tunny, which exceed it by nearly ten degrees. Among insects, the range is from two to ten degrees above that of the air: the excess varying according to their activity. The heat of reptiles is from four to fifteen degrees more than that of their medium. While mammals and birds maintain a heat which continues almost unaffected by external variations, and is often greater than that of the air by seventy, eighty, ninety, and even a hundred degrees.

Once more, in greater *self-mobility* a progressive differentiation is traceable. Dead matter is inert: some form of independent motion is our most general test of life. Passing over the indefinite border-land between the animal and vegetable kingdoms, we may roughly class plants as organisms which, while they exhibit the kind of motion implied in growth, are not only without locomotive power, but in nearly all cases are without the power of moving their parts in relation to one another; and thus are less differentiated from the inorganic world than animals. Though in those microscopic *Protophyta* and *Protozoa* inhabiting the water – the spores of algæ, the gemmules of sponges, and the infusoria generally – we see locomotion produced by ciliary action; yet this locomotion, while rapid relatively to their sizes, is absolutely slow. Of the *Cœlenterata*, a great part are either permanently rooted or habitually stationary, and so have scarcely any self-mobility but that implied in the relative movements of parts; while the rest, of which the common jelly-fish serves as a sample, have mostly but little ability to move themselves through the water. Among the higher aquatic *Invertebrata*, – cuttle-fishes and lobsters, for instance, – there is a very considerable power of locomotion; and the aquatic *Vertebrata* are, considered as a class, much more active in their movements than the other inhabitants of the water. But it is only when we come to air-breathing creatures that we find the vital characteristic of self-mobility manifested in the highest degree. Flying insects, mammals, birds, travel with velocities far exceeding those attained by any of the lower classes of animals; and so are more strongly contrasted with their inert environments.

Thus, on contemplating the various grades of organisms in their ascending order, we find them more and more distinguished from their inanimate media in *structure*, in *form*, in *chemical composition*, in *specific gravity*, in *temperature*, in *self-mobility*. It is true that this generalization does not hold with regularity. Organisms which are in some respects the most strongly contrasted with the inorganic world, are in other respects less contrasted than inferior organisms. As a class, mammals are higher than birds; and yet they are of lower temperature, and have smaller powers of locomotion. The stationary oyster is of higher organization than the free-swimming medusa; and the cold-blooded and less heterogeneous fish is quicker in its movements than the warm-blooded and more heterogeneous sloth. But the admission that the several aspects under which this increasing contrast shows itself bear variable ratios to one another, does not negative the general truth enunciated. Looking at the facts in the mass, it cannot be denied that the successively higher groups of organisms are severally characterized, not only by greater differentiation of parts, but also by greater differentiation from the surrounding medium in sundry other physical attributes. It would seem that this peculiarity has some necessary connexion with superior vital manifestations. One of those lowly gelatinous forms which are some of them so transparent and colourless as to be with difficulty distinguished from the water they float in, is not more like its medium in chemical, mechanical, optical, thermal, and other properties, than it is in the passivity with which it submits to all the actions brought to bear on it; while the mammal does not more widely differ from inanimate things in these properties than it does in the activity with which it meets surrounding changes by compensating changes in itself. Between these two extremes, we see a tolerably constant ratio between these two kinds of contrast. In proportion as an organism is physically like its environment it remains a passive partaker of the changes going on in its environment; while in proportion as it is endowed with powers of counteracting such changes, it exhibits greater unlikeness to its environment.

Thus far we have proceeded inductively, in conformity with established usage; but it seems to us that much may be done in this and other departments of biologic inquiry by pursuing the deductive method. The generalizations at present constituting the science of physiology, both general and special, have been reached *a posteriori*; but certain fundamental data have now been discovered, starting from which we may reason our way *a priori*, not only to some of the truths that have been ascertained by observation and experiment, but also to some others. The possibility of such *a priori* conclusions will be at once recognized on considering some familiar cases.

Chemists have shown that a necessary condition to vital activity in animals is oxidation of certain matters contained in the body either as components or as waste products. The oxygen requisite for this oxidation is contained in the surrounding medium – air or water, as the case may be. If the organism be minute, mere contact of its external surface with the oxygenated medium achieves the requisite oxidation; but if the organism is bulky, and so exposes a surface which is small in proportion to its mass, any considerable oxidation cannot be thus achieved. One of two things is therefore implied. Either this bulky organism, receiving no oxygen but that absorbed through its integument, must possess but little vital activity; or else, if it possesses much vital activity, there must be some extensive ramified surface, internal or external, through which adequate aeration may take place – a respiratory apparatus. That is to say, lungs, or gills, or branchiæ, or their equivalents, are predicable *a priori* as possessed by all active creatures of any size.

Similarly with respect to nutriment. There are *entozoa* which, living in the insides of other animals, and being constantly bathed by nutritive fluids, absorb a sufficiency through their outer surfaces; and so have no need of stomachs, and do not possess them. But all other animals, inhabiting media that are not in themselves nutritive, but only contain masses of food here and there, must have appliances by which these masses of food may be utilized. Evidently mere external contact of a solid organism with a solid portion of nutriment, could not result in the absorption of it in any moderate time, if at all. To effect absorption, there must be both a solvent or macerating action, and an extended surface fit for containing and imbibing the dissolved products: there must be a digestive cavity. Thus, given the ordinary conditions of animal life, and the possession of stomachs by all creatures living under these conditions may be deductively known.

Carrying out the train of reasoning still further, we may infer the existence of a vascular system or something equivalent to it, in all creatures of any size and activity. In a comparatively small inert animal, such as the hydra, which consists of little more than a sac having a double wall – an outer layer of cells forming the skin, and an inner layer forming the digestive and absorbent surface – there is no need for a special apparatus to diffuse through the body the aliment taken up; for the body is little more than a wrapper to the food it encloses. But where the bulk is considerable, or where the activity is such as to involve much waste and repair, or where both these characteristics exist, there is a necessity for a system of blood-vessels. It is not enough that there be adequately extensive surfaces for absorption and aeration; for in the absence of any means of conveyance, the absorbed elements can be of little or no use to the organism at large. Evidently there must be channels of communication. When, as in the *Medusæ*, we find these channels of communication consisting simply of branched canals opening out of the stomach and spreading through the disk, we may know, *a priori*, that such creatures are comparatively inactive; seeing that the nutritive liquid thus partially distributed throughout their bodies is crude and dilute, and that there is no efficient appliance for keeping it in motion. Conversely, when we meet with a creature of considerable size which displays much vivacity, we may know, *a priori*, that it must have an apparatus for the unceasing supply of concentrated nutriment, and of oxygen, to every organ – a pulsating vascular system.

It is manifest, then, that setting out from certain known fundamental conditions to vital activity, we may deduce from them sundry of the chief characteristics of organized bodies.

Doubtless these known fundamental conditions have been inductively established. But what we wish to show is that, given these inductively-established primary facts in physiology, we may with safety draw certain general deductions from them. And, indeed, the legitimacy of such deductions, though not formally acknowledged, is practically recognized in the convictions of every physiologist, as may be readily proved. Thus, were a physiologist to find a creature exhibiting complex and variously co-ordinated movements, and yet having no nervous system; he would be less astonished at the breach of his empirical generalization that all such creatures have nervous systems, than at the disproof of his unconscious deduction that all creatures exhibiting complex and variously co-ordinated movements must have an "internuncial" apparatus by which the co-ordination may be effected. Or were he to find a creature having blood rapidly circulated and rapidly aerated, but yet showing a low temperature, the proof so afforded that active change of matter is not, as he had inferred from chemical data, the cause of animal heat, would stagger him more than would the exception to a constantly-observed relation. Clearly, then, the *a priori* method already plays a part in physiological reasoning. If not ostensibly employed as a means of reaching new truths, it is at least privately appealed to for confirmation of truths reached *a posteriori*.

But the illustrations above given go far to show, that it may to a considerable extent be safely used as an independent instrument of research. The necessities for a nutritive system, a respiratory system, and a vascular system, in all animals of size and vivacity, seem to us legitimately inferable from the conditions to continued vital activity. Given the physical and chemical data, and these structural peculiarities may be deduced with as much certainty as may the hollowness of an iron ball from its power of floating in water.

It is not, of course, asserted that the more *special* physiological truths can be deductively reached. The argument by no means implies this. Legitimate deduction presupposes adequate data; and in respect to the *special* phenomena of organic growth, structure, and function, adequate data are unattainable, and will probably ever remain so. It is only in the case of the more *general* physiological truths, such as those above instanced, where we have something like adequate data, that deductive reasoning becomes possible.

And here is reached the stage to which the foregoing considerations are introductory. We propose now to show that there are certain still more general attributes of organized bodies, which are deducible from certain still more general attributes of things.

In an essay on "Progress: its Law and Cause," elsewhere published,[8] we have endeavoured to show that the transformation of the homogeneous into the heterogeneous, in which all progress, organic or other, essentially consists, is consequent on

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[8] In the *Westminster Review* for April, 1857; and now reprinted in this volume.

the production of many effects by one cause – many changes by one force. Having pointed out that this is a law of all things, we proceeded to show deductively that the multiform evolutions of the homogeneous into the heterogeneous – astronomic, geologic, ethnologic, social, &c., – were explicable as consequences. And though in the case of organic evolution, lack of data disabled us from specifically tracing out the progressive complication as due to the multiplication of effects; yet, we found sundry indirect evidences that it was so. Now in so far as this conclusion, that organic evolution results from the decomposition of each expended force into several forces, was inferred from the general law previously pointed out, it was an example of deductive physiology. The particular was concluded from the universal.

We here propose in the first place to show, that there is another general truth closely connected with the above; and in common with it underlying explanations of all progress, and therefore the progress of organisms – a truth which may indeed be considered as taking precedence of it in respect of time, if not in respect of generality. This truth is, that *the condition of homogeneity is a condition of unstable equilibrium*.

The phrase *unstable equilibrium* is one used in mechanics to express a balance of forces of such kind, that the interference of any further force, however minute, will destroy the arrangement previously existing, and bring about a different arrangement. Thus, a stick poised on its lower end is in unstable equilibrium: however exactly it may be placed in a perpendicular position, as soon as it is left to itself it begins, at first imperceptibly and then visibly, to lean on one side, and with increasing rapidity falls into another position. Conversely, a stick suspended from its upper end is in stable equilibrium: however much disturbed, it will return to the same position. Our meaning is, then, that the state of homogeneity, like the state of the stick poised on its lower end, is one that cannot be maintained; and that hence results the first step in its gravitation towards the heterogeneous. Let us take a few illustrations.

Of mechanical ones the most familiar is that of the scales. If accurately made and not clogged by dirt or rust, a pair of scales cannot be perfectly balanced: eventually one scale will descend and the other ascend – they will assume a heterogeneous relation. Again, if we sprinkle over the surface of a liquid a number of equal-sized particles, having an attraction for one another, they will, no matter how uniformly distributed, by and by concentrate irregularly into groups. Were it possible to bring a mass of water into a state of perfect homogeneity – a state of complete quiescence, and exactly equal density throughout – yet the radiation of heat from neighbouring bodies, by affecting differently its different parts, would soon produce inequalities of density and consequent currents; and would so render it to that extent heterogeneous. Take a piece of red-hot matter, and however evenly heated it may at first be, it will quickly cease to be so: the exterior, cooling faster than the interior, will become different in temperature from it. And the lapse into heterogeneity of temperature, so obvious in this extreme case, is ever taking place more or less in all cases. The actions of chemical forces supply other illustrations. Expose a fragment of metal to air or water, and in course of time it will be coated with a film of oxide, carbonate, or other compound: its outer parts will become unlike its inner parts. Thus, every homogeneous aggregate of matter tends to lose its balance in some way or other – either mechanically, chemically, thermally or electrically; and the rapidity with which it lapses into a non-homogeneous state is simply a question of time and circumstances. Social bodies illustrate the law with like constancy. Endow the members of a community with equal properties, positions, powers, and they will forthwith begin to slide into inequalities. Be it in a representative assembly, a railway board, or a private partnership, the homogeneity, though it may continue in name, inevitably disappears in reality.

The instability thus variously illustrated becomes still more manifest if we consider its rationale. It is consequent on the fact that the several parts of any homogeneous mass are necessarily exposed to different forces – forces which differ either in their kinds or amounts; and being exposed to different forces they are of necessity differently modified. The relations of outside and inside, and of comparative nearness to neighbouring sources of influence, imply the reception of influences which are unlike in quantity or quality or both; and it follows that unlike changes will be wrought in the parts dissimilarly acted upon. The unstable equilibrium of any homogeneous aggregate can thus be shown both inductively and deductively.

And now let us consider the bearing of this general truth on the evolution of organisms. The germ of a plant or animal is one of these homogeneous aggregates – relatively homogeneous if not absolutely so – whose equilibrium is unstable. But it has not simply the ordinary instability of homogeneous aggregates: it has something more. For it consists of units which are themselves specially characterized by instability. The constituent molecules of organic matter are distinguished by the feebleness of the affinities which hold their component elements together. They are extremely sensitive to heat, light, electricity, and the chemical actions of foreign elements; that is, they are peculiarly liable to be modified by disturbing forces. Hence then it follows, *a priori*, that a homogeneous aggregate of these unstable molecules will have an excessive tendency to lose its equilibrium. It will have a quite special liability to lapse into a non-homogeneous state. It will rapidly gravitate towards heterogeneity.

Moreover, the process must repeat itself in each of the subordinate groups of organic units which are differentiated by the modifying forces. Each of these subordinate groups, like the original group, must gradually, in obedience to the influences acting on it, lose its balance of parts – must pass from a uniform into a multiform state. And so on continuously.

Thus, starting from the general laws of things, and the known chemical attributes of organic matter, we may conclude deductively that the homogeneous germs of organisms have a peculiar proclivity towards a non-homogeneous state; which may be either the state we call decomposition, or the state we call organization.

At present we have reached a conclusion only of the most general nature. We merely learn that *some* kind of heterogeneity is inevitable; but as yet there is nothing to tell us *what* kind. Besides that *orderly* heterogeneity which distinguishes organisms, there is the *disorderly* or *chaotic* heterogeneity, into which a loose mass of inorganic matter lapses; and at present no reason has been given why the homogeneous germ of a plant or animal should not lapse into the disorderly instead of the orderly heterogeneity. But by pursuing still further the line of argument hitherto followed we shall find a reason.

We have seen that the instability of homogeneous aggregates in general, and of organic ones in particular, is consequent on the various ways and degrees in which their constituent parts are exposed to the disturbing forces brought to bear on them: their parts are differently acted upon, and therefore become different. Manifestly, then, a rationale of the special changes which a germ undergoes, must be sought in the particular relations which its several parts bear to each other and to their environment. However it may be masked, we may suspect the fundamental principle of organization to be, that the many like units forming a germ acquire those kinds and degrees of unlikeness which their respective positions entail.

Take a mass of unorganized but organizable matter – either the body of one of the lowest living forms, or the germ of one of the higher. Consider its circumstances. It is immersed in water or air; or it is contained within a parent organism. Wherever placed, however, its outer and inner parts stand differently related to surrounding existences – nutriment, oxygen, and the various stimuli. But this is not all. Whether it lies quiescent at the bottom of the water, whether it moves through the water preserving some definite attitude, or whether it is in the inside of an adult; it equally results that certain parts of its surface are more directly exposed to surrounding agencies than other parts – in some cases more exposed to light, heat, or oxygen, and in others to the maternal tissues and their contents. The destruction of its original equilibrium is therefore certain. It may take place in one of two ways. Either the disturbing forces may be such as to overbalance the affinities of the organic elements, in which case there results that chaotic heterogeneity known as decomposition; or, as is ordinarily the case, such changes are induced as do not destroy the organic compounds, but only modify them: the parts most exposed to the modifying forces being most modified. Hence result those first differentiations which constitute incipient organization. From the point of view thus reached, suppose we look at a few cases: neglecting for the present all consideration of the tendency to assume the inherited type.

Note first what appear to be exceptions, as the *Amœba*. In this creature and its allies, the substance of the jelly-like body remains throughout life unorganized – undergoes no permanent differentiations. But this fact, which seems directly opposed to our inference, is really one of the most significant evidences of its truth. For what is the peculiarity of the Rhizopods, exemplified by the *Amœba*? They undergo perpetual and irregular changes of shape – they show no persistent relations of parts. What lately formed a portion of the interior is now protruded, and, as a temporary limb, is attached to some object it happens to touch. What is now a part of the surface will presently be drawn, along with the atom of nutriment sticking to it, into the centre of the mass. Thus there is an unceasing interchange of places; and the relations of inner and outer have no settled existence. But by the hypothesis, it is only in virtue of their unlike positions with respect to modifying forces, that the originally-like units of a living mass become unlike. We must not therefore expect any established differentiation of parts in creatures which exhibit no established differences of position in their parts.

This negative evidence is borne out by abundant positive evidence. When we turn from these ever-changing specks of living jelly to organisms having unchanging distributions of substance, we find differences of tissue corresponding to differences of relative position. In all the higher *Protozoa*, as also in the *Protophyta*, we meet with a fundamental differentiation into cell-membrane and cell-contents, answering to that fundamental contrast of conditions implied by the words outside and inside. And on passing from what are roughly classed as unicellular organisms to the lowest of those which consist of aggregated cells, we equally observe the connexion between structural differences and differences of circumstance. In the sponge, permeated throughout by currents of sea-water, the absence of definite organization corresponds with the absence of definite unlikeness of conditions. In the *Thalassicolla* of Professor Huxley – a transparent, colourless body, found floating passively at the surface of the sea, and consisting essentially of "a mass of cells united by jelly" – there is displayed a rude structure obviously subordinated to the primary relations of centre and surface: in all of its many and important varieties, the parts exhibit a more or less concentric arrangement.

After this primary modification, by which the outer tissues are differentiated from the inner, the next in order of constancy and importance is that by which some part of the outer tissues is differentiated from the rest; and this corresponds with the almost universal fact that some part of the outer tissues is more directly exposed to certain environing influences than the rest. Here, as before, the apparent exceptions are extremely significant. Some of the lowest vegetable organisms, as the *Hematococci* and *Protococci*, evenly imbedded in a mass of mucus, or dispersed through the Arctic snow, display no differentiations of surface: the several parts of the surface being subjected to no definite contrasts of conditions. The *Thalassicolla* above mentioned, unfixed, and rolled about by the waves, presents all its sides successively to the same agencies; and all its sides are alike. A ciliated sphere like the *Volvox* has no parts of its periphery unlike other parts; and it is not to be expected that it should have; seeing that as it revolves in all directions, it does not, in traversing the water, permanently expose any part to special conditions. But when we come to creatures that are either fixed, or while moving, severally preserve a definite attitude, we no longer find uniformity of surface. The gemmule of a Zoophyte, which during its locomotive stage is distinguishable only into outer and inner tissues, no sooner takes root than its upper end begins to assume a different structure from its lower. The free-swimming embryo of an aquatic annelid, being ovate and not ciliated all over, moves with one end foremost; and its differentiations proceed in conformity with this contrast of circumstances.

The principle thus displayed in the humbler forms of life, is traceable during the development of the higher; though being here soon masked by the assumption of the hereditary type, it cannot be traced far. Thus the "mulberry-mass" into which a fertilized ovum of a vertebrate animal first resolves itself, soon begins to exhibit a difference between the outer and inner parts answering to the difference of circumstances. The peripheral cells, after reaching a more complete development than the central ones, coalesce into a membrane enclosing the rest; and then the cells lying next to these outer ones become aggregated with them, and increase the thickness of the germinal membrane, while the central cells liquefy. Again, one part of the germinal membrane presently becomes distinguishable as the germinal spot; and without asserting that the cause of this is to be found in the unlike relations which the respective parts of the germinal membrane bear to environing influences, it is clear that we have in these unlike relations an element of disturbance tending to destroy the original homogeneity of the germinal membrane. Further, the germinal membrane by and by divides into two layers, internal and external; the one in contact with the liquefied interior part or yelk, the other exposed to the surrounding fluids: this contrast of circumstances being in obvious correspondence with the contrast of structures which follows it. Once more, the subsequent appearance of the vascular layer between these mucous and serous layers, as they have been named, admits of a like interpretation. And in this and the various complications which now begin to show themselves, we may see coming into play that general law of the multiplication of effects flowing from one cause, to which the increase of heterogeneity was elsewhere ascribed.[9]

Confining our remarks, as we do, to the most general facts of development, we think that some light is thus thrown on them. That the unstable equilibrium of a homogeneous germ must be destroyed by the unlike exposure of its several units to surrounding influences, is an *a priori* conclusion. And it seems also to be an *a priori* conclusion, that the several units thus differently acted upon, must either be decomposed, or

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[9] See Essay on "Progress: its Law and Cause."

must undergo such modifications of nature as may enable them to live in the respective circumstances they are thrown into: in other words —*they must either die or become adapted to their conditions*. Indeed, we might infer as much without going through the foregoing train of reasoning. The superficial organic units (be they the outer cells of a "mulberry-mass," or be they the outer molecules of an individual cell) must assume the function which their position necessitates; and assuming this function, must acquire such character as performance of it involves. The layer of organic units lying in contact with the yelk must be those through which the yelk is absorbed; and so must be adapted to the absorbent office. On this condition only does the process of organization appear possible. We might almost say that just as some race of animals, which multiplies and spreads into divers regions of the earth, becomes differentiated into several races through the adaptation of each to its conditions of life; so, the originally homogeneous population of cells arising in a fertilized germ-cell, becomes divided into several populations of cells that grow unlike in virtue of the unlikeness of their circumstances.

Moreover, it is to be remarked in further proof of our position, that it finds its clearest and most abundant illustrations where the conditions of the case are the simplest and most general – where the phenomena are the least involved: we mean in the production of individual cells. The structures which presently arise round nuclei in a blastema, and which have in some way been determined by those nuclei as centres of influence, evidently conform to the law; for the parts of the blastema in contact with the nuclei are differently conditioned from the parts not in contact with them. Again, the formation of a membrane round each of the masses of granules into which the endochrome of an alga-cell breaks up, is an instance of analogous kind. And should the recently-asserted fact that cells may arise round vacuoles in a mass of organizable substance, be confirmed, another good example will be furnished; for such portions of substance as bound these vacant spaces are subject to influences unlike those to which other portions of the substance are subject. If then we can most clearly trace this law of modification in these primordial processes, as well as in those more complex but analogous ones exhibited in the early changes of an ovum, we have strong reason for thinking that the law is fundamental.

But, as already more than once hinted, this principle, understood in the simple form here presented, supplies no key to the detailed phenomena of organic development. It fails entirely to explain generic and specific peculiarities; and leaves us equally in the dark respecting those more important distinctions by which families and orders are marked out. Why two ova, similarly exposed in the same pool, should become the one a fish, and the other a reptile, it cannot tell us. That from two different eggs placed under the same hen, should respectively come forth a duckling and a chicken, is a fact not to be accounted for on the hypothesis above developed. Here we are obliged to fall back upon the unexplained principle of hereditary transmission. The capacity possessed by an unorganized germ of unfolding into a complex adult which repeats ancestral traits in minute details, and that even when it has been placed in conditions unlike those of its ancestors, is a capacity impossible for us to understand. That a microscopic portion of seemingly structureless matter should embody an influence of such kind, that the resulting man will in fifty years after become gouty or insane, is a truth which would be incredible were it not daily illustrated. But though the *manner* in which hereditary likeness, in all its complications, is conveyed, is a mystery passing comprehension, it is quite conceivable that it is conveyed in subordination to the law of adaptation above explained; and we are not without reasons for thinking that it is so. Various facts show that acquired peculiarities resulting from the adaptation of constitution to conditions, are transmissible to offspring. Such acquired peculiarities consist of differences of structure or composition in one or more of the tissues. That is to say, of the aggregate of similar organic units composing a germ, the group going to the formation of a particular tissue, will take on the special character which the adaptation of that tissue to new circumstances had produced in the parents. We know this to be a general law of organic modifications. Further, it is the *only* law of organic modifications of which we have any evidence.[10] It is not impossible then that it is the universal law; comprehending

[10] This was written before the publication of the *Origin of Species*. I leave it standing because it shows the stage of thought then arrived at.

not simply those minor modifications which offspring inherit from recent ancestry, but comprehending also those larger modifications distinctive of species, genus, order, class, which they inherit from antecedent races of organisms. And thus it *may be* that the law of adaptation is the sole law; presiding not only over the differentiation of any race of organisms into several races, but also over the differentiation of the race of organic units composing a germ, into the many races of organic units composing an adult. So understood, the process gone through by every unfolding organism will consist, partly in the direct adaptation of its elements to their several circumstances, and partly in the assumption of characters resulting from analogous adaptations of the elements of all ancestral organisms.

But our argument does not commit us to any such far-reaching speculation as this; which we introduce simply as suggested by it, not involved. All we are here concerned to show, is, that the deductive method aids us in interpreting some of the more general phenomena of development. That all homogeneous aggregates are in unstable equilibrium is a universal truth, from which is deducible the instability of every organic germ. From the known sensitiveness of organic compounds to chemical, thermal, and other disturbing forces, we further infer the *unusual* instability of every organic germ – a proneness far beyond that of other homogeneous aggregates to lapse into a heterogeneous state. By the same line of reasoning we are led to the additional inference, that the first divisions into which a germ resolves itself, being severally in a state of unstable equilibrium, are similarly prone to undergo further changes; and so on continuously. Moreover, we have found it to be equally an *a priori* conclusion, that as, in all other cases, the loss of homogeneity is due to the different degrees and kinds of force brought to bear on the different parts; so, in this case too, difference of circumstances is the primary cause of differentiation. Add to which, that as the several changes undergone by the respective parts thus diversely acted upon, are changes which do not destroy their vital activity, they must be changes which bring that vital activity into subordination to the incident forces – they must be adaptations; and the like must be in some sense true of all the subsequent changes. Thus by deductive reasoning we get some insight into the method of organization. However unable we are, and probably ever shall be, to comprehend the way in which a germ is made to take on the special form of its race, we may yet comprehend the general principles which regulate its first modifications; and, remembering the unity of plan so conspicuous throughout nature, we may *suspect* that these principles are in some way concerned in succeeding modifications.

A controversy now going on among zoologists, opens yet another field for the application of the deductive method. We believe that the question whether there does or does not exist a *necessary correlation* among the several parts of an organism is determinable *a priori*.

Cuvier, who first asserted this necessary correlation, professed to base his restorations of extinct animals upon it. Geoffroy St. Hilaire and De Blainville, from different points of view, contested Cuvier's hypothesis; and the discussion, which has much interest as bearing on paleontology, has been recently revived under a somewhat modified form: Professors Huxley and Owen being respectively the assailant and defender of the hypothesis.

Cuvier says – "Comparative anatomy possesses a principle whose just development is sufficient to dissipate all difficulties; it is that of the correlation of forms in organized beings, by means of which every kind of organized being might, strictly speaking, be recognized by a fragment of any of its parts. Every organized being constitutes a whole, a single and complete system, whose parts mutually correspond and concur by their reciprocal reaction to the same definite end. None of these parts can be changed without affecting the others; and consequently each taken separately, indicates and gives all the rest." He then gives illustrations: arguing that the carnivorous form of tooth necessitating a certain action of the jaw, implies a particular form in its condyles; implies also limbs fit for seizing and holding prey; therefore implies claws, a certain structure of the leg-bones, a certain form of shoulder-blade. Summing up he says, that "the claw, the scapula, the condyle, the femur, and all the other bones, taken separately, will give the tooth or one another; and by commencing with any one, he who had a rational conception of the laws of the organic economy, could reconstruct the whole animal."

It will be seen that the method of restoration here contended for, is based on the alleged physiological necessity of the connexion between these several peculiarities. The argument used is, not that a scapula of a certain shape may be recognized as having belonged to a carnivorous mammal because we always find that carnivorous mammals *do* possess such scapulas; but the argument is that they *must* possess them, because carnivorous habits would be impossible without them. And in the above quotation Cuvier asserts that the necessary correlation which he considers so obvious in these cases, exists throughout the system: admitting, however, that in consequence of our limited knowledge of physiology we are unable in many cases to trace this necessary correlation, and are obliged to base our conclusions upon observed coexistences, of which we do not understand the reason, but which we find invariable.

Now Professor Huxley has recently shown that, in the first place, this empirical method, which Cuvier introduces as quite subordinate, and to be used only in aid of the rational method, is really the method which Cuvier habitually employed – the so-called rational method remaining practically a dead letter; and, in the second place, he has shown that Cuvier himself has in several places so far admitted the inapplicability of the rational method, as virtually to surrender it as a method. But more than this, Professor Huxley contends that the alleged necessary correlation is not true. Quite admitting the physiological dependence of parts on each other, he denies that it is a dependence of a kind which could not be otherwise. "Thus the teeth of a lion and the stomach of the animal are in such relation that the one is fitted to digest the food which the other can tear, they are physiologically correlated; but we have no reason for affirming this to be a necessary physiological correlation, in the sense that no other could equally fit its possessor for living on recent flesh. The number and form of the teeth might have been quite different from that which we know them to be, and the construction of the stomach might have been greatly altered; and yet the functions of these organs might have been equally well performed."

Thus much is needful to give an idea of the controversy. It is not here our purpose to go more at length into the evidence cited on either side. We simply wish to show that the question may be settled deductively. Before going on to do this, however, let us briefly notice two collateral points.

In his defence of the Cuvierian doctrine, Professor Owen avails himself of the *odium theologicum*. He attributes to his opponents "the insinuation and masked advocacy of the doctrine subversive of a recognition of the Higher Mind." Now, saying nothing about the questionable propriety of thus prejudging an issue in science, we think this is an unfortunate accusation. What is there in the hypothesis of *necessary*, as distinguished from *actual*, correlation of parts, which is particularly in harmony with Theism? Maintenance of the *necessity*, whether of sequences or of coexistences, is commonly thought rather a derogation from divine power than otherwise. Cuvier says – "None of these parts can be changed without affecting the others; and consequently, each taken separately, indicates and gives all the rest." That is to say, in the nature of things the correlation *could not* have been otherwise. On the other hand, Professor Huxley says we have no warrant for asserting that the correlation *could not* have been otherwise; but have not a little reason for thinking that the same physiological ends might have been differently achieved. The one doctrine limits the possibilities of creation; the other denies the implied limit. Which, then, is most open to the charge of covert Atheism?

On the other point we lean to the opinion of Professor Owen. We agree with him in thinking that where a rational correlation (in the highest sense of the term) can be made out, it affords a better basis for deduction than an empirical correlation ascertained only by accumulated observations. Premising that by rational correlation is not meant one in which we can trace, or think we can trace, a design, but one of which the negation is inconceivable (and this is the species of correlation which Cuvier's principle implies); then we hold that our knowledge of the correlation is of a more certain kind than where it is simply inductive. We think that Professor Huxley, in his anxiety to avoid the error of making Thought the measure of Things, does not sufficiently bear in mind the fact, that as our notion of necessity is determined by some absolute uniformity pervading all orders of our experiences, it follows that an organic correlation which cannot be conceived otherwise, is guaranteed by a much wider induction than one ascertained only by the observation of organisms. But the truth is, that there are relatively few organic correlations of which the negation is inconceivable. If we find the skull, vertebræ, ribs, and phalanges of some quadruped as large as an elephant; we may indeed be certain that the legs of this quadruped were of considerable size – much larger than those of a rat; and our reason for conceiving this correlation as necessary, is, that it is based, not only upon our experiences of moving organisms, but upon all our mechanical experiences relative to masses and their supports. But even were there many physiological correlations really of this order, which there are not, there would be danger in pursuing this line of reasoning, in consequence of the liability to include within the class of truly necessary correlations, those which are not such. For instance, there would seem to be a necessary correlation between the eye and the surface of the body: light being needful for vision, it might be supposed that every eye must be external. Nevertheless it is a fact that there are creatures, as the *Cirrhipedia*, having eyes (not very efficient ones, it may be) deeply imbedded within the body. Again, a necessary correlation might be assumed between the dimensions of the mammalian uterus and those of the pelvis. It would appear impossible that in any species there should exist a well-developed uterus containing a full-sized fœtus, and yet that the arch of the pelvis should be too small to allow the fœtus to pass. And were the only mammal having a very small pelvic arch, a fossil one, it would have been inferred, on the Cuvierian method, that the fœtus must have been born in a rudimentary state; and that the uterus must have been proportionally small. But there happens to be an extant mammal having an undeveloped pelvis – the mole – which presents us with a fact that saves us from this erroneous inference. The young of the mole are not born through the pelvic arch at all; but in front of it! Thus, granting that some quite *direct* physiological correlations may be necessary, we see that there is great risk of including among them some which are not.

With regard to the great mass of the correlations, however, including all the *indirect* ones, Professor Huxley seems to us warranted in denying that they are necessary; and we now propose to show deductively the truth of his thesis. Let us begin with an analogy.

Whoever has been through an extensive iron-works, has seen a gigantic pair of shears worked by machinery, and used for cutting in two, bars of iron that are from time to time thrust between its blades. Supposing these blades to be the only visible parts of the apparatus, anyone observing their movements (or rather the movement of one, for the other is commonly fixed), will see from the manner in which the angle increases and decreases, and from the curve described by the moving extremity, that there must be some centre of motion – either a pivot or an external box equivalent to it. This may be regarded as a necessary correlation. Moreover, he might infer that beyond the centre of motion the moving blade was produced into a lever, to which the power was applied; but as another arrangement is just possible, this could not be called anything more than a highly probable correlation. If now he went a step further, and asked how the reciprocal movement was given to the lever, he would perhaps conclude that it was given by a crank. But if he knew anything of mechanics, he would know that it might possibly be given by an eccentric. Or again, he would know that the effect could be achieved by a cam. That is to say, he would see that there was no necessary correlation between the shears and the remoter parts of the apparatus. Take another case. The plate of a printing-press is required to move up and down to the extent of an inch or so; and it must exert its greatest pressure when it reaches the extreme of its downward movement. If now anyone will look over the stock of a printing-press maker, he will see half a dozen different mechanical arrangements by which these ends are achieved; and a machinist would tell him that as many more might readily be invented. If, then, there is no necessary correlation between the special parts of a machine, still less is there between those of an organism.

From a converse point of view the same truth is manifest. Bearing in mind the above analogy, it will be foreseen that an alteration in one part of an organism will not necessarily entail *some one specific set of alterations in the other parts*. Cuvier says, "None of these parts can be changed without affecting the others;

and consequently, each taken separately, indicates and gives all the rest." The first of these propositions may pass, but the second, which it is alleged follows from it, is not true; for it implies that "all the rest" can be severally affected in only one way and degree, whereas they can be affected in many ways and degrees. To show this, we must again have recourse to a mechanical analogy.

If you set a brick on end and thrust it over, you can predict with certainty in what direction it will fall, and what attitude it will assume. If, again setting it up, you put another on the top of it, you can no longer foresee with accuracy the results of an overthrow; and on repeating the experiment, no matter how much care is taken to place the bricks in the same positions, and to apply the same degree of force in the same direction, the effects will on no two occasions be exactly alike. And in proportion as the aggregation is complicated by the addition of new and unlike parts, will the results of any disturbance become more varied and incalculable. The like truth is curiously illustrated by locomotive engines. It is a fact familiar to mechanical engineers and engine-drivers, that out of a number of engines built as accurately as possible to the same pattern, no two will act in just the same manner. Each will have its peculiarities. The play of actions and reactions will so far differ, that under like conditions each will behave in a somewhat different way; and every driver has to learn the idiosyncrasies of his own engine before he can work it to the greatest advantage. In organisms themselves this indefiniteness of mechanical reaction is clearly traceable.

Two boys throwing stones will always differ more or less in their attitudes, as will two billiard-players. The familiar fact that each individual has a characteristic gait, illustrates the point still better. The rhythmical motion of the leg is simple, and on the Cuvierian hypothesis, should react on the body in some uniform way. But in consequence of those slight differences of structure which consist with identity of species, no two individuals make exactly similar movements either of the trunk or the arms. There is always a peculiarity recognizable by their friends.

When we pass to disturbing forces of a non-mechanical kind, the same truth becomes still more conspicuous. Expose several persons to a drenching storm; and while one will subsequently feel no appreciable inconvenience, another will have a cough, another a catarrh, another an attack of diarrhœa, another a fit of rheumatism. Vaccinate several children of the same age with the same quantity of virus, applied to the same part, and the symptoms will not be quite alike in any of them, either in kind or intensity; and in some cases the differences will be extreme. The quantity of alcohol which will send one man to sleep, will render another unusually brilliant – will make this maudlin, and that irritable. Opium will produce either drowsiness or wakefulness: so will tobacco.

Now in all these cases – mechanical and other – some force is brought to bear primarily on one part of an organism, and secondarily on the rest; and, according to the doctrine of Cuvier, the rest ought to be affected in a specific way. We find this to be by no means the case. The original change produced in one part does not stand in any necessary correlation with every one of the changes produced in the other parts; nor do these stand in any necessary correlation with one another. The functional alteration which the disturbing force causes in the organ directly acted upon, does not involve some *particular set* of functional alterations in the other organs; but will be followed by some one out of various sets. And it is a manifest corollary, that any *structural alteration* which may eventually be produced in the one organ, will not be accompanied by *some particular set of structural alterations* in the other organs. There will be no necessary correlation of forms.

Thus Paleontology must depend upon the empirical method. A fossil species that was obliged to change its food or habits of life, did not of necessity undergo the particular set of modifications exhibited; but, under some slight change of predisposing causes – as of season or latitude – might have undergone some other set of modifications: the determining circumstance being one which, in the human sense, we call fortuitous.

May we not say then, that the deductive method elucidates this vexed question in physiology; while at the same time our argument collaterally exhibits the limits within which the deductive method is applicable. For while we see that this extremely *general* question may be satisfactorily dealt with deductively; the conclusion arrived at itself implies that the more *special* phenomena of organization cannot be so dealt with.

There is yet another method of investigating the general truths of physiology – a method to which physiology already owes one luminous idea, but which is not at present formally recognized as a method. We refer to the comparison of physiological phenomena with social phenomena.

The analogy between individual organisms and the social organism, is one that has from early days occasionally forced itself on the attention of the observant. And though modern science does not countenance those crude ideas of this analogy which have been from time to time expressed since the Greeks flourished; yet it tends to show that there *is* an analogy, and a remarkable one. While it is becoming clear that there are not those special parallelisms between the constituent parts of a man and those of a nation, which have been thought to exist; it is also becoming clear that the general principles of development and structure displayed in organized bodies are displayed in societies also. The fundamental characteristic both of societies and of living creatures, is, that they consist of mutually-dependent parts; and it would seem that this involves a community of various other characteristics. Those who are acquainted with the broad facts of both physiology and sociology, are beginning to recognize this correspondence not as a plausible fancy, but as a scientific truth. And we are strongly of opinion that it will by and by be seen to hold to an extent which few at present suspect.

Meanwhile, if any such correspondence exists, it is clear that physiology and sociology will more or less interpret each other. Each affords its special facilities for inquiry. Relations of cause and effect clearly traceable in the social organism, may lead to the search for analogous ones in the individual organism; and may so elucidate what might else be inexplicable. Laws of growth and function disclosed by the pure physiologist, may occasionally give us the clue to certain social modifications otherwise difficult to understand. If they can do no more, the two sciences can at least exchange suggestions and confirmations; and this will be no small aid. The conception of "the physiological division of labour," which political economy has already supplied to physiology, is one of no small value. And probably it has others to give.

In support of this opinion, we will now cite cases in which such aid is furnished. And in the first place, let us see whether the facts of social organization do not afford additional support to some of the doctrines set forth in the foregoing parts of this article.

One of the propositions supported by evidence was that in animals the process of development is carried on, not by differentiations only, but by subordinate integrations. Now in the social organism we may see the same duality of process; and further, it is to be observed that the integrations are of the same three kinds. Thus we have integrations which arise from the simple growth of adjacent parts that perform like functions: as, for instance, the coalescence of Manchester with its calicoweaving suburbs. We have other integrations which arise when, out of several places producing a particular commodity, one monopolizes more and more of the business, and leaves the rest to dwindle: witness the growth of the Yorkshire cloth-districts at the expense of those in the west of England; or the absorption by Staffordshire of the pottery-manufacture, and the consequent decay of the establishments that once flourished at Worcester, Derby, and elsewhere. And we have those yet other integrations which result from the actual approximation of the similarly-occupied parts: whence result such facts as the concentration of publishers in Paternoster Row, of lawyers in the Temple and neighbourhood, of corn-merchants about Mark Lane, of civil engineers in Great George Street, of bankers in the centre of the city. Finding thus that in the evolution of the social organism, as in the evolution of individual organisms, there are integrations as well as differentiations, and moreover that these integrations are of the same three orders; we have additional reason for considering these integrations as essential parts of the developmental process, needed to be included in its formula. And further, the circumstance that in the social organism these integrations are determined by community of function, confirms the hypothesis that they are thus determined in the individual organism.

Again, we endeavoured to show deductively, that the contrasts of parts first seen in all unfolding embryos, are consequent upon the contrasted circumstances to which such parts are exposed; that thus, adaptation of constitution to conditions is the principle which determines their primary changes; and that, possibly, if we include under the formula hereditarily-transmitted adaptations, all subsequent differentiations may be similarly determined. Well, we need not long contemplate the facts to see that some of the predominant social differentiations are brought about in an analogous way. As the members of an originally-homogeneous community multiply and spread, the gradual separation into sections which simultaneously takes place, manifestly depends on differences of local circumstances. Those who happen to live near some place chosen, perhaps for its centrality, as one of periodical assemblage, become traders, and a town springs up; those who live dispersed, continue to hunt or cultivate the earth; those who spread to the sea-shore fall into maritime occupations. And each of these classes undergoes modifications of character fitting to its function. Later in the process of social evolution these local adaptations are greatly multiplied. In virtue of differences of soil and climate, the rural inhabitants in different parts of the kingdom, have their occupations partially specialized; and are respectively distinguished as chiefly producing cattle, or sheep, or wheat, or oats, or hops, or cider. People living where coal-fields are discovered become colliers; Cornishmen take to mining because Cornwall is metalliferous; and the iron-manufacture is the dominant industry where ironstone is plentiful. Liverpool has assumed the office of importing cotton, in consequence of its proximity to the district where cotton goods are made; and for analogous reasons Hull has become the chief port at which foreign wools are brought in. Even in the establishment of breweries, of dye-works, of slate-quarries, of brick-yards, we may see the same truth. So that, both in general and in detail, these industrial specializations of the social organism which characterize separate districts, primarily depend on local circumstances. Of the originally-similar units making up the social mass, different groups assume the different functions which their respective positions entail; and become adapted to their conditions. Thus, that which we concluded, *a priori*, to be the leading cause of organic differentiations, we find, *a posteriori*, to be the leading cause of social differentiations. Nay further, as we inferred that possibly the embryonic changes which are not thus directly caused, are caused by hereditarily-transmitted adaptations; so, we may actually see that in embryonic societies, such changes as are not due to direct adaptations, are in the main traceable to adaptations originally undergone by the parent society. The colonies founded by distinct nations, while they are alike in exhibiting specializations caused in the way above described, grow unlike in so far as they take on, more or less, the organizations of the nations they sprung from. A French settlement does not develop exactly after the same manner as an English one; and both assume forms different from those which Roman settlements assumed. Now the fact that the differentiation of societies is determined partly by the direct adaptation of their units to local conditions, and partly by the transmitted influence of like adaptations undergone by ancestral societies, tends strongly to enforce the conclusion, otherwise reached, that the differentiation of individual organisms, similarly results from immediate adaptations compounded with ancestral adaptations.

From confirmations thus furnished by sociology to physiology, let us now pass to a suggestion similarly furnished. A factory, or other producing establishment, or a town made up of such establishments, is an agency for elaborating some commodity consumed by society at large; and may be regarded as analogous to a gland or viscus in an individual organism. If we inquire what is the primitive mode in which one of these producing establishments grows up, we find it to be this. A single worker, who himself sells the produce of his labour, is the germ. His business increasing, he employs helpers – his sons or others; and having done this, he becomes a vendor not only of his own handiwork, but of that of others. A further increase of his business compels him to multiply his assistants, and his sale grows so rapid that he is obliged to confine himself to the process of selling: he ceases to be a producer, and becomes simply a channel through which the produce of others is conveyed to the public. Should his prosperity rise yet higher, he finds that he is unable to manage even the sale of his commodities, and has to employ others, probably of his own family, to aid him in selling; so that, to him as a main channel are now added subordinate channels. Moreover, when there grow up in one place, as a Manchester or a Birmingham, many establishments of like kind, this process is carried still further. There arise factors and buyers, who are the channels through which is transmitted the produce of many factories; and we believe that primarily these factors were manufacturers who undertook to dispose of the produce of smaller houses as well as their own, and ultimately became salesmen only. Under a converse aspect, all the stages of this development have been within these few years exemplified in our railway contractors. There are sundry men now living who illustrate the whole process in their own persons – men who were originally navvies, digging and wheeling; who then undertook some small sub-contract, and worked along with those they paid; who presently took larger contracts, and employed foremen; and who now contract for whole railways, and let portions to sub-contractors. That is to say, we have men who were originally workers, but have finally become the main channels out of which diverge secondary channels, which again bifurcate into the subordinate channels, through which flows the money (representing the nutriment) supplied by society to the actual makers of the railway. Now it seems worth inquiring whether this is not the original course followed in the evolution of secreting and excreting organs in an animal. We know that such is the process by which the liver is developed. Out of the group of bile-cells forming the germ of it, some centrally-placed ones, lying next to the intestine, are transformed into ducts through which the secretion of the peripheral bile-cells is poured into the intestine; and as the peripheral bile-cells multiply, there similarly arise secondary ducts emptying themselves into the main ones; tertiary ones into these; and so on. Recent inquiries show that the like is the case with the lungs, – that the bronchial tubes are thus formed. But while analogy suggests that this is the *original* mode in which such organs are developed, it at the same time suggests that this does not necessarily continue to be the mode. For as we find that in the social organism, manufacturing establishments are no longer commonly developed through the series of modifications above described, but now mostly arise by the direct transformation of a number of persons into master, clerks, foremen, workers, &c.; so the approximate method of forming organs, may in some cases be replaced by a direct metamorphosis of the organic units into the destined structure, without any transitional structures being passed through. That there are organs thus formed is an ascertained fact; and the additional question which analogy suggests is, whether the direct method is substituted for the indirect method.

Such parallelisms might be multiplied. And were it possible here to show in detail the close correspondence between the two kinds of organization, our case would be seen to have abundant support. But, as it is, these few illustrations will sufficiently justify the opinion that study of organized bodies may be indirectly furthered by study of the body politic. Hints may be expected, if nothing more. And thus we venture to think that the

Inductive Method, usually alone employed by most physiologists, may not only derive important assistance from the Deductive Method, but may further be supplemented by the Sociological Method.

THE NEBULAR HYPOTHESIS

[*First published in* The Westminster Review *for July,* 1858. *In explanation of sundry passages, it seems needful to state that this essay was written in defence of the Nebular Hypothesis at a time when it had fallen into disrepute. Hence there are some opinions spoken of as current which are no longer current.*]

Inquiring into the pedigree of an idea is not a bad means of roughly estimating its value. To have come of respectable ancestry, is *prima facie* evidence of worth in a belief as in a person; while to be descended from a discreditable stock is, in the one case as in the other, an unfavourable index. The analogy is not a mere fancy. Beliefs, together with those who hold them, are modified little by little in successive generations; and as the modifications which successive generations of the holders undergo do not destroy the original type, but only disguise and refine it, so the accompanying alterations of belief, however much they purify, leave behind the essence of the original belief.

Considered genealogically, the received theory respecting the creation of the Solar System is unmistakably of low origin. You may clearly trace it back to primitive mythologies. Its remotest ancestor is the doctrine that the celestial bodies are personages who originally lived on the Earth – a doctrine still held by some of the negroes Livingstone visited. Science having divested the sun and planets of their divine personalities, this old idea was succeeded by the idea which even Kepler entertained, that the planets are guided in their courses by presiding spirits: no longer themselves gods, they are still severally kept in their orbits by gods. And when gravitation came to dispense with these celestial steersmen, there was begotten a belief, less gross than its parent, but partaking of the same essential nature, that the planets were originally launched into their orbits by the Creator's hand. Evidently, though much refined, the anthropomorphism of the current hypothesis is inherited from the aboriginal anthropomorphism, which described gods as a stronger order of men.

There is an antagonist hypothesis which does not propose to honour the Unknown Power manifested in the Universe, by such titles as "The Master-Builder," or "The Great Artificer;" but which regards this Unknown Power as probably working after a method quite different from that of human mechanics. And the genealogy of this hypothesis is as high as that of the other is low. It is begotten by that ever-enlarging and ever-strengthening belief in the presence of Law, which accumulated experiences have gradually produced in the human mind. From generation to generation Science has been proving uniformities of relation among phenomena which were before thought either fortuitous or supernatural in their origin – has been showing an established order and a constant causation where ignorance had assumed irregularity and arbitrariness. Each further discovery of Law has increased the presumption that Law is everywhere conformed to. And hence, among other beliefs, has arisen the belief that the Solar System originated, not by *manufacture* but by *evolution*. Besides its abstract parentage in those grand general conceptions which Science has generated, this hypothesis has a concrete parentage of the highest character. Based as it is on the law of universal gravitation, it may claim for its remote progenitor the great thinker who established that law. It was first suggested by one who ranks high among philosophers. The man who collected evidence indicating that stars result from the aggregation of diffused matter, was the most diligent, careful, and original astronomical observer of modern times. And the world has not seen a more learned mathematician than the man who, setting out with this conception of diffused matter concentrating towards its centre of gravity, pointed out the way in which there would arise, in the course of its concentration, a balanced group of sun, planets, and satellites, like that of which the Earth is a member.

Thus, even were there but little direct evidence assignable for the Nebular Hypothesis, the probability of its truth would be strong. Its own high derivation and the low derivation of the antagonist hypothesis, would together form a weighty reason for accepting it – at any rate, provisionally. But the direct evidence assignable for the Nebular Hypothesis is by no means little. It is far greater in quantity, and more varied in kind, than is commonly supposed. Much has been said here and there on this or that class of evidences; but nowhere, so far as we know, have all the evidences been fully stated. We propose here to do something towards supplying the deficiency: believing that, joined with the *a priori* reasons given above, the array of *a posteriori* reasons will leave little doubt in the mind of any candid inquirer.

And first, let us address ourselves to those recent discoveries in stellar astronomy which have been supposed to conflict with this celebrated speculation.

When Sir William Herschel, directing his great reflector to various nebulous spots, found them resolvable into clusters of stars, he inferred, and for a time maintained, that all nebulous spots are clusters of stars exceedingly remote from us. But after years of conscientious investigation, he concluded that "there were nebulosities which are not of a starry nature;" and on this conclusion was based his hypothesis of a diffused luminous fluid which, by its eventual aggregation, produced stars. A telescopic power much exceeding that used by Herschel, has enabled Lord Rosse to resolve some of the nebulæ previously unresolved; and, returning to the conclusion which Herschel first formed on similar grounds but afterwards rejected, many astronomers have assumed that, under sufficiently high powers, every nebula would be decomposed into stars – that the irresolvability is due solely to distance. The hypothesis now commonly entertained is, that all nebulæ are galaxies more or less like in nature to that immediately surrounding us; but that they are so inconceivably remote as to look, through ordinary telescopes, like small faint spots. And not a few have drawn the corollary, that by the discoveries of Lord Rosse the Nebular Hypothesis has been disproved.

Now, even supposing that these inferences respecting the distances and natures of the nebulæ are valid, they leave the Nebular Hypothesis substantially as it was. Admitting that each of these faint spots is a sidereal system, so far removed that its countless stars give less light than one small star of our own sidereal system; the admission is in no way inconsistent with the belief that stars, and their attendant planets, have been formed by the aggregation of nebulous matter. Though, doubtless, if the existence of nebulous matter now in course of concentration be disproved, one of the evidences of the Nebular Hypothesis is destroyed, yet the remaining evidences remain. It is a tenable position that though nebular condensation is now nowhere to be seen in progress, yet it was once going on universally. And, indeed, it might be argued that the still-continued existence of diffused nebulous matter is scarcely to be expected; seeing that the causes which have resulted in the aggregation of one mass, must have been acting on all masses, and that hence the existence of masses not aggregated would be a fact calling for explanation. Thus, granting the immediate conclusions suggested by these recent disclosures of the six-feet reflector, the corollary which many have drawn is inadmissible.

But these conclusions may be successfully contested. Receiving them though we have been, for years past, as established truths, a critical examination of the facts has convinced us that they are quite unwarrantable. They involve so many manifest incongruities, that we have been astonished to find men of science entertaining them, even as probable. Let us consider these incongruities.

In the first place, mark what is inferable from the distribution of nebulæ.

> "The spaces which precede or which follow simple nebulæ," says Arago, "and *a fortiori*, groups of nebulæ, contain generally few stars. Herschel found this rule to be invariable. Thus every time that during a short interval no star approached in virtue of the diurnal motion, to place itself in the field of his motionless telescope, he was accustomed to say to the secretary who assisted him, – 'Prepare to write; nebulæ are about to arrive.'"

How does this fact consist with the hypothesis that nebulæ are remote galaxies? If there were but one nebula, it would be a curious coincidence were this one nebula so placed in the distant regions of space, as to agree in direction with a starless spot in our own sidereal system. If there were but two nebulæ, and both were so placed, the coincidence would be excessively strange. What, then, shall we say on finding that there are thousands of nebulæ so placed? Shall we believe that in thousands of cases these far-removed galaxies happen to agree in their visible positions with the thin places in our own galaxy? Such a belief is impossible.

Still more manifest does the impossibility of it become when we consider the general distribution of nebulæ. Besides again showing itself in the fact that "the poorest regions in stars are near the richest in nebulæ," the law above specified applies to the heavens as a whole. In that zone of celestial space where stars are excessively abundant, nebulæ are rare; while in the two opposite celestial spaces that are furthest removed from this zone, nebulæ are abundant. Scarcely any nebulæ lie near the galactic circle (or plane of the Milky Way); and the great mass of them lie round the galactic poles. Can this also be mere coincidence? When to the fact that the general mass of nebulæ are antithetical in position to the general mass of stars, we add the fact that local regions of nebulæ are regions where stars are scarce, and the further fact that single nebulæ are habitually found in comparatively starless spots; does not the proof of a physical connexion become overwhelming? Should it not require an infinity of evidence to show that nebulæ are not parts of our sidereal system? Let us see whether any such infinity of evidence is assignable. Let us see whether there is even a single alleged proof which will bear examination.

> "As seen through colossal telescopes," says Humboldt, "the contemplation of these nebulous masses leads us into regions from whence a ray of light, according to an assumption not wholly improbable, requires millions of years to reach our earth – to distances for whose measurement the dimensions (the distance of Sirius, or the calculated distances of the binary stars in Cygnus and the Centaur) of our nearest stratum of fixed stars scarcely

suffice."

In this confused sentence there is implied a belief, that the distances of the nebulæ from our galaxy of stars as much transcend the distances of our stars from one another, as these interstellar distances transcend the dimensions of our planetary system. Just as the diameter of the Earth's orbit, is a mere point when compared with the distance of our Sun from Sirius; so is the distance of our Sun from Sirius, a mere point when compared with the distance of our galaxy from those far-removed galaxies constituting nebulæ. Observe the consequences of this assumption.

If one of these supposed galaxies is so remote that its distance dwarfs our interstellar spaces into points, and therefore makes the dimensions of our whole sidereal system relatively insignificant; does it not inevitably follow that the telescopic power required to resolve this remote galaxy into stars, must be incomparably greater than the telescopic power required to resolve the whole of our own galaxy into stars? Is it not certain that an instrument which can just exhibit with clearness the most distant stars of our own cluster, must be utterly unable to separate one of these remote clusters into stars? What, then, are we to think when we find that the same instrument which decomposes hosts of nebulæ into stars, *fails* to resolve completely our own Milky Way? Take a homely comparison. Suppose a man who was surrounded by a swarm of bees, extending, as they sometimes do, so high in the air as to render some of the individual bees almost invisible, were to declare that a certain spot on the horizon was a swarm of bees; and that he knew it because he could see the bees as separate specks. Incredible as the assertion would be, it would not exceed in incredibility this which we are criticising. Reduce the dimensions to figures, and the absurdity becomes still more palpable. In round numbers, the distance of Sirius from the Earth is half a million times the distance of the Earth from the Sun; and, according to the hypothesis, the distance of a nebula is something like half a million times the distance of Sirius. Now, our own "starry island, or nebula," as Humboldt calls it, "forms a lens-shaped, flattened, and everywhere detached stratum, whose major axis is estimated at seven or eight hundred, and its minor axis at a hundred and fifty times the distance of Sirius from the Earth."[11] And since it is concluded that the Solar System is near the centre of this aggregation, it follows that our distance from the remotest parts of it is some four hundred distances of Sirius. But the stars forming these remotest parts are not individually visible, even through telescopes of the highest power. How, then, can such telescopes make individually visible the stars of a nebula which is half a million times the distance of Sirius? The implication is, that a star rendered invisible by distance becomes visible if taken twelve hundred times further off! Shall we accept this implication? or shall we not rather conclude that the nebulæ are *not* remote galaxies? Shall we not infer that, be their nature what it may, they must be at least as near to us as the extremities

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[11] *Cosmos.* (Seventh Edition.) Vol. i. pp. 79, 80.

of our own sidereal system?

Throughout the above argument, it is tacitly assumed that differences of apparent magnitude among the stars, result mainly from differences of distance. On this assumption the current doctrines respecting the nebulæ are founded; and this assumption is, for the nonce, admitted in each of the foregoing criticisms. From the time, however, when it was first made by Sir W. Herschel, this assumption has been purely gratuitous; and it now proves to be inadmissible. But, awkwardly enough, its truth and its untruth are alike fatal to the conclusions of those who argue after the manner of Humboldt. Note the alternatives.

On the one hand, what follows from the untruth of the assumption? If apparent largeness of stars is not due to comparative nearness, and their successively smaller sizes to their greater and greater degrees of remoteness, what becomes of the inferences respecting the dimensions of our sidereal system and the distances of nebulæ? If, as has lately been shown, the almost invisible star 61 Cygni has a greater parallax than [Greek: a] Cygni, though, according to an estimate based on Sir W. Herschel's assumption, it should be about twelve times more distant – if, as it turns out, there exist telescopic stars which are nearer to us than Sirius; of what worth is the conclusion that the nebulæ are very remote, because their component luminous masses are made visible only by high telescopic powers? Clearly, if the most brilliant star in the heavens and a star that cannot be seen by the naked eye, prove to be equidistant, relative distances cannot be in the least inferred from relative visibilities. And if so, nebulæ may be comparatively near, though the starlets of which they are made up appear extremely minute.

On the other hand, what follows if the truth of the assumption be granted? The arguments used to justify this assumption in the case of the stars, equally justify it in the case of the nebulæ. It cannot be contended that, on the average, the *apparent* sizes of the stars indicate their distances, without its being admitted that, on the average, the *apparent* sizes of the nebulæ indicate their distances – that, generally speaking, the larger are the nearer and the smaller are the more distant. Mark, now, the necessary inference respecting their resolvability. The largest or nearest nebulæ will be most easily resolved into stars; the successively smaller will be successively more difficult of resolution; and the irresolvable ones will be the smallest ones. This, however, is exactly the reverse of the fact. The largest nebulæ are either wholly irresolvable, or but partially resolvable under the highest telescopic powers; while large numbers of quite small nebulæ are easily resolved by far less powerful telescopes. An instrument through which the great nebula in Andromeda, two and a half degrees long and one degree broad, appears merely as a diffused light, decomposes a nebula of fifteen minutes diameter into twenty thousand starry points. At the same time that the individual stars of a nebula eight minutes in diameter are so clearly seen as to allow of their number being estimated, a nebula covering an area five hundred times as great shows no stars at all! What possible explanation of this can be given on the current hypothesis?

Yet a further difficulty remains – one which is, perhaps, still more obviously fatal than the foregoing. This difficulty is presented by the phenomena of the Magellanic clouds. Describing the larger of these, Sir John Herschel says: —

> "The Nubecula Major, like the Minor, consists partly of large tracts and ill-defined patches of irresolvable nebula, and of nebulosity in every stage of resolution, up to perfectly resolved stars like the Milky Way, as also of regular and irregular nebulæ properly so called, of globular clusters in every stage of resolvability, and of clustering groups sufficiently insulated and condensed to come under the designation of 'clusters of stars.'" —*Cape Observations*

Конец ознакомительного фрагмента.