THE SYSTEM OF ANIMATE NATURE

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THE CONCEPT OF EVOLUTION.

There are two fundamental biological questions: What are living creatures, statically and dynamically, intact and in all their parts?; and, How have they come to be as they are, individually and racially? In the preceding ten lectures we have been concerned with organisms as they are; we pass now to the problem of their evolution. Our general aim remains:—to state the outstanding results of a scientific study of Animate Nature, so that it may be seen whether they are conformable with other results of human experience. We do not argue from the empirical facts to any transcendental conclusion, for that is bound to be bad argument. We try to state the facts.

§ 1. *A Question of Terms.*

It must be confessed that the study of organic evolution has been hampered by a plethora of words and a dearth of facts. This is not unnatural, for the idea of testing evolutionary hypotheses concretely is hardly older than Darwin, and the shortness of human life is discouraging to experimentation with organisms. The results of many years are usually small in amount. It is only now and then that a pioneer like Mendel is able to take a great stride, and to give his successors a clue that enables them to take others. Impatient therefore of the slow but sure inductive method, naturalists are ever flying kites of hypotheses and there is no department of science so wordy as ætiology.

On the other hand, one of the difficulties is that we have too few words. The same word is used with many meanings, and, like a tool put to many uses, becomes blunted and fallacious. So is it with the word 'evolution'.

Whatever be his personal classification every one recognises that there are in our world three spheres which overlap one another. There is the cosmosphere—from the solar system to the dew-drop, from the moon to the moonstone, from the sea to the snow-crystal—the Domain of the Inorganic, where formulations are in terms of matter and motion—formulations, which, whether they exhaust the reality or not, get close enough to it to be thoroughly reliable for practical purposes and ventures.

Secondly, there is the biosphere, the Realm of Organisms, where the laws of matter and motion still hold, but are no longer exhaustive, since another aspect of reality has welled-up, which we call life. And since even simple un-bodied creatures go a-hunting and show purposive behaviour, we find it difficult to separate off life from mind. We cannot say much about plants which we do not know how to waken from their dreams, but for the animal world we have clearly to do in any typical case with a Body-Mind or Mind-Body.

Thirdly, there is the sociosphere, the Kingdom of Man, where mechanism is in many departments transcended or sublimed, where even the science of the individual is transcended, for human beings in societies behave in a way which cannot be formulated in terms of individual Biology and Psychology. The homing bird transcends the boomerang, and a purely Natural History account of social activity or social evolution leaves much out.

So we have:—

the Kingdom of Man
the Realm of Organisms
and the Domain of the Inorganic

well marked off from one another, and it seems on the face of it likely that fallacy will result from using the same word 'evolution' for all the processes of becoming that are observable in these diverse fields. We hear of the evolution of the solar system, of scenery, of chemical elements, the evolution of organisms, of species, of consciousness, of mind, of man, the evolution of societary forms, of institutions, of language, of religions, the evolution of evolution-theories. Now the use of the same word, especially a semi-technical word, suggests that we have to do throughout with a similar, perhaps a continuous process. But this begs several questions. No matter how convinced we may be as to Continuity, we must not assume that the processes that have led to the inorganic domain being what it is are also those which account for the becoming of organisms, or that human history is nothing more than a continuation of organic evolution. A staircase is continuous, but there are successive steps, and so in evolution there seem to have been epoch-making steps of 'creative synthesis'.

The following suggestions as to terms are offered. For the process of becoming in the inorganic domain, when there is more or less lasting change from one form of equilibrium to another, we might perhaps use the word genesis, and speak, for clearness sake, of the genesis of the solar system or of the moon. Many geologists speak of the genesis of ores and mountain-ranges. It is clear that in the case of the solar system, for instance, we have nothing like the succession of generations, nothing like the sifting process, nothing like the experimenting with existences which is so characteristic of that sublime adventure which we call organic evolution.

In the realm of organisms let us use the word development for the individual's becoming, for its ontogeny, for the expression of the inheritance amid appropriate nurture. Let us keep the word evolution for the phylogeny of the race as distinguished from the ontogeny of the individual.

Then let us keep the word history for the human Kingdom of ends, where social persons are the new actualities.

What words are used matters, perhaps, little; the point is that fallacy may be lessened by using differential terms, by speaking of the genesis of the solar system, the development of the chick, the evolution of birds, and the history of institutions.

§ 2. *The Evolution of Organisms Contrasted with Inorganic Genesis.*

Looking backwards, we may say that evolution within the realm of organisms differs from genesis in the domain of the inorganic in three outstanding ways. First, the discrete material systems involved are organisms,—more than mechanisms, a differentia which implies, as we have seen, alternatives, genuine agency, endeavour, some measure of profitable enregistering of experiences, and in certain cases the efficiency of what we call mind.

Secondly, the capacity of organic variation which is distinctive of living creatures, is only adumbrated among non-living things. A living unity, whether a full-grown organism or an implicit organism (the germ-cell), gives rise to something new. A genius is born, a mutation occurs; this is something apart from the ubiquitous flux of weathering, rusting, and the like in the inorganic world. The latter corresponds to the wear and tear of organisms, the disintegration and ageing, the incorporation of the substance of one creature into that of another. It is one thing to say with the Greek philosopher "all things flow"; it is another to recognise creative evolution. For an approach to organic variation we must look to such phenomena as the change of one crystalline form into another, or the elaboration of a carbon compound in certain surroundings, or, nearest of all, perhaps, the change of Uranium into Radium and Helium.

But, third, when an inorganic material system—whether a cloud or a mineral—changes from one form or phase to another, it has its analogue rather in organic *development* than in organic *evolution.* For organic evolution implies a succession of generations, a staking of individual lives and losing them, a sacrifice of variants and of types and even of races, a sifting so that many who run the race and fight the fight with success fail eventually to inherit the promises. Even if the chemical evolutionist gives us a genealogical tree of Radium-lead, through Radium to Uranium (with successive losses of Helium), we have only an analogy to organic pedigree.

It is indeed tempting to compare the conflict of forces in the inorganic domain and the resulting equilibrium with the struggle for existence among organisms and the resulting adaptations, to compare both with the conflict of human races and what may result therefrom, but it is probably more fallacious than useful. The similarities are at best formal, except that in all cases—in inorganic genesis, in organic evolution, and in social history—we are dealing with processes of change.

We dwell on these distinctions because they are not really easy, because they are often ignored, and because our whole system of thought depends on our answer to the question whether organic evolution is adequately described as a mechanical process. In his famous article in the 9th edition of the *Encyclopædia Britannica,* Prof. James Sully defined evolution as a "natural history of the cosmos, including organic beings, expressed in physical terms as a mechanical process". We have given some reasons for regarding this definition as scientifically unsound. The vital striving and struggling characteristic of the realm of organisms is something apart from and finer than even the music of the spheres.

Let us give the contrast we are emphasising its most generalised statement. From the purely physical point of view—a very abstract one—the history of the world has been and continues to be a series of re-distributions of matter and energy. Even if we think of radium pouring forth power like an inexhaustible fountain, we make it conform with physical theory by speaking of the potential energy liberated by a dissolution of the atoms. The world is like a change-office, without increase or decrease in its initial stock. We always stand in the middle of an equation, past equalling future. It is for the biologist to correct this partial view, for to him the possible that grows out of the past is new and in some measure unpredictable. The psychologist has a similar task. M. Bergson has done great service in emphasising this truth.

§ 3. *Organic Evolution Contrasted with the History of Human Societies.*

Looking forwards now, we may recognise that organic evolution differs from the history of human society in three outstanding ways. (1) The variations that count among plants and animals are changes in the germ-plasm, but the moving and shaking of the Kingdom of Man need not be thus restricted, as is obvious in 'revivals' and 'revolutions', for instance, which are certainly *social* variations. (2) The important evolutionary registration among plants and animals is in the natural inheritance, but in the Kingdom of Man the extra-organismal or social heritage bulks largely. (3) Among social animals there is not more than a dim adumbration of what is characteristic in mankind,—that a social ideal of some sort is defined, and that organisations are formed, both on the temporal and spiritual side, to realise it.

The naturalist is not disposed to agree with a too facile exaggeration of the difference made by the fact that Man is a social person. There is a great deal of what might be called social tissue at pre-human levels. Especially on the instinctive line of evolution are there quaint forms of social organisation which command our admiration though for ethical reasons we cannot take any imitative advantage of their subtlety. There is amazement for us in the sterile worker-caste in bees, in the soldier-caste among termites, in the massacres of the superfluous, in the nutritive partnership between many wasps and their young larvæ—mothers feeding young and young feeding mothers, in the way the tailor-ants use their children as needle and thread!

§ 4. *Definition of the Concept of Organic Evolution.*

By a method of contrast, then, we are seeking to render more precise the concept of organic evolution. It is distinguishable from the genesis of the solar system or of a range of mountains, and from the history of political institutions or social usages. Moreover, we speak of the development of the chick, but of the evolution of birds. What more can be said? Organic evolution is a continuous natural process of racial change in a definite direction whereby distinctively new individualities arise, take root, and flourish, sometimes alongside of, and sometimes, sooner or later, in place of the originative stock. The domestic breeds of pigeons and fowls are apparently the results of evolutionary change whose origins are still with us in the Rock Dove and the Jungle Fowl. In the Crab-Apple by the wayside, whose promise is more obviously suggested by its flowers than by its fruit, there is the sturdy plebeian ancestor of all the delicate aristocrats of the orchard; into the unpromising wild kale by the sea-shore we have to read back all our cabbages, cauliflowers, and curly greens. In these and in many other cases the original stock still persists.

It is otherwise, however, when we inquire into the origin of creatures like the domestic horse or dog; the only certainty is our ignorance. And this is even more emphatic when we try to discover the pedigree of any of the great classes of animals: Whence came mammals or birds? What was the origin of molluscs or of insects? In many cases the ancestral stocks are unknown; in other cases where they have been detected by some probability they are separated by great gaps from their modern descendants. In general, while there are long-lived conservative types, like Lingula, which persist, with little change or none, from age to age, evolution has meant replacement of old by new.

In many cases what we dimly descry is a vigorous stock from which tentative offshoots arise, which lead to much or to little, while the main branch grows on and, as if it were purified, gives rise to fine fruit. Thus from the early Primate stock there diverged off at various levels New World Monkeys, Old World Monkeys, small Apes and great Apes, leaving a humanoid branch none the worse, to say the least.

In a concrete way the concept of Evolution means that the present is the child of the past and the parent of the future, that the present-day fauna and flora and all the system of inter-relations have arisen in a natural knowable way from a preceding state of affairs on the whole somewhat simpler, and that from forms and inter-relations simpler still, and so on backwards till we lose all clues in the thick mist of life's beginnings.

"As in the development of a fugue," Samuel Butler said, "where when the subject and counter-subject have been announced, there must thenceforth be nothing new, and yet all must be new, so throughout organic nature—which is a fugue developed to great length from a very simple subject—everything is linked on to and grows out of that which comes next to it in order—errors and omissions excepted."

§ 5. *May Evolution Have Been a Process of Analytic Simplifying, not of Synthetic Complexifying?*

Since the publication of the *Origin of Species* there have been various outcrops of the idea that the process of evolution may have been not by synthetic complexifying but by analytic emancipation or exfoliation of originally complex buds. An Italian naturalist has at great length sought to show that reptiles evolved from birds, not birds from reptiles, and the backboneless from the backboned, not the other way round. This reads like a modern version of the suggestion made by Plato in the Timæus that the whole organic world might be formed by degradation from man who was created first. No one has taken these heretical views very seriously, if only for the reason that the rock record is wholly against such an interpretation of what has occurred. A general survey shows that amphibians appeared after fishes, and reptiles after ampihibians, and birds after reptiles. A more detailed survey of particular lineages, like that of horses or elephants, shows that the earlier forms in the series are the more generalised.

But while a crude topsy-turvy view must be dismissed without hesitation, some find good reason to pause before rejecting the idea that the process of evolution may have been analytic not synthetic. We must remember that the concrete problem of accounting for any of the leading types of organisms or any of the so-called big lifts in evolution is extraordinarily difficult and very far from solution. We must remember that it is extremely difficult to suggest a theory of the origin of the distinctively new. We must remember that in the cases of evolution that are nearest to us, namely in domestic animals and cultivated plants, what is suggested by the facts is not synthetic complexifying but analytic simplification. We are delightedly familiar with the range of colours in modern Sweet Peas, but have we realised the Mendelian conclusion that these are all due to an unpacking of the inheritance of the wild ancestor—which was brought from Sicily at the end of the seventeenth century? There is no doubt, Professor Bateson tells us, that our cultivated Sweet Peas "have been derived from the one wild bi-colour form by a process of successive removals". (Presidential Address Brit. Association, Australia, 1914, p. 18.)

Professor Bateson is one of the foremost living ætiologists, and respect is due to his pronouncement that we must begin seriously to consider "whether the course of Evolution can at all reasonably be represented as an unpacking of an original complex, which contained within itself the whole range of diversity which living things present. . . . As we have got to recognise that there has been an Evolution, that somehow or other the forms of life have arisen from fewer forms, we may as well see whether we are limited to the old view that evolutionary progress is from the simple to the complex, and whether after all it is conceivable that the process was the other way about . . . . At first it may seem rank absurdity to suppose that the primordial form or forms of protoplasm could have contained complexity enough to produce the divers types of life. But is it easier to imagine that these powers could have been conveyed by extrinsic additions?"

Professor Bateson asks us not to think of the primordial forms of life as necessarily very simple. We are to think of them as richly endowed with initiatives and potentialities. He is particularly inclined to this view because his extraordinarily fine experimental work has led him to conclude that most of the novelties that appear nowadays in garden and breeding-pen are due to the removal of hindrances that suppress or mask underlying qualities. There has been an unpacking of a crowded treasure-box and a placing of assorted jewels in special caskets. Mr. Bateson appears to believe that the reason why we are not all geniuses is not that we have not got it in us, but that we cannot get it out. When the genius emerges it is not really a new achievement that has been made, it is that certain hindrances or inhibitors have been removed. So the process of evolution has been a succession of liberations rather than of achievements, a succession of gains by loss.

In this interesting theory we recognise two truths: first, that when genuine living creatures did first appear as going concerns, they had within them the secret of a possible glorious future (*ce n'est que le premier pas qui coûte*); and second, that many apparently novel acquisitions are due to the removal of some inhibitor or some mask or some complexity in the hindrance. We are unwilling, however, to accept Professor Bateson's picture as a complete one, and that for several reasons. (1) The first is that it makes the origin and nature of the primordial organisms too utterly miraculous if we suppose them to have had such a rich stock of initiatives and implications. (2) It seems to lead to a very mechanical picture of evolution, as if it were just an age-long unrolling of a stupendous gramophone record. Time is required for unrolling the record, but time does not count for the gramophone, as it counts for the organism *which trades with it.* Space is required for unrolling the record, but space does not count for the gramophone as it counts for the organism, *which trafficks with its environment.* (3) Given an artistic genius, we may assert that all that he did in the last forty years of his life was in him when he was twenty-one. But is this necessarily an accurate statement? His achievements at thirty are the product of his hereditary nature, admittedly well-expressed at his coming of age, but also of what he has made of his life and his chances, and of what society has made of him. The organism works on a compound interest principle; especially in its mental aspect it is made as well as born. And what is true of an explicit individual that he makes experiments in self-expression may be true for aught we know of those implicit, telescoped-down individualities which we call germ-cells. In any case, we see no reason to part with the idea of the full-grown organism as an agent that shares in its own evolution.

In so far as Professor Bateson's view is just a paradoxical way of saying that there is nothing evolved which was not, in kind, originally involved; that there is nothing of lasting value in the end which was not present, in kind, in the beginning, we have no fault to find with it, provided it be clearly recognised that it necessitates the assumption that the ancestral creatures had the primordia of mental as well as of bodily organisation. If we ourselves are asked to state how we conceive that the Primordials did embody all the promise and potency of, say, bee-kind, or bird-kind, or man-kind, we cannot answer, except by suggesting that the question is not rightly put. What the Primordials embodied was the next stage in the Systema Naturæ.

But if Mr. Bateson's view implies that the apparent origin of the new is illusory, that creative evolution is a fiction, that evolution means unfolding (evolutio) not new-formation (epigenesis), it does not seem to us to be in accordance with the facts.

In the study of individual development embryologists have to do with the emergence of the obviously complex from the apparently simple. We mean by apparently simple that the egg has no organs or tissues or the like, but all the modern work on germ-cells points to the conclusion that for each distinct feature in the adult there is in the germ-cell a *something* which divides and persists. Thus arises what Prof. E. B. Wilson calls the puzzle of the microcosm: "Is the hen's egg fundamentally as complex as the hen, and is development merely the transformation of one kind of complexity into another"?

We can picture a conjurer's box full of exquisite wound-up contrivances which begin to unwind and expand one after the other when the lid is opened. As the springs uncoil an extraordinarily complex mass is formed which half fills the stage. But there is no real increase in complexity, even if the springs interlace. For a tangled skein is not more complex than an ordered one. Now, development is much more than this uncoiling of springs set agoing by opening the lid of a box, for each cell into which the egg-cell divides is a living unit and is able to relate itself in an organic way to its neighbours, so that the final result is a dynamic system—an active organisation—far more complex than the original egg-cell.

What holds in the development of the microcosm is true also in the evolution of the macrocosm. The descendants are really more complex than the primordial ancestors, for the process has meant a multiplication of genuine individualities or agents, who relate themselves to one another organically, who enter into subtle inter-relations with their inanimate environment, whence also new complexities spring.

A number of immigrants on a prospecting voyage take possession of an island and in the course of centuries a great nation is built up. All the human material in that nation has arisen from what was in the ship, but it outrages common sense to maintain that the end is not more complex than the beginning, for that is to deny to men and women any creative agency, to pretend that inter-relations established by genuine agents do not spell new organisation. This view reduces human history to the level of a puppet-show; in short, it is a false simplicity, a 'materialism'.

What biology seems justified in holding firm to is, that there has been a frequent epigenesis or new formation, a frequent outcrop of genuine novelties. Without insisting on the epigenetic character of the emergence of feeling and other forms of consciousness, we mean, in concrete language, that there was a time when there were no insects; they came into being, and they were new ideas. There was a time when there were no birds; they came into being, and they were new ideas. It may be very naïve on the biologist's part, but it does not appear likely that any argument that being is a fixed quantity will affect his belief that insects and birds were downright novelties. Evolution is racial epigenesis—the making actual of what was only potential; but it is more, it is a series of great inventions,—in a way, a succession of new worlds.

§ 6. *The Logical Validity of the Evolution Formula.*

The evolution formula is not demonstrable like that of gravitation. It is a way of looking at things that fits, that is luminous, that meets with no contradiction, that serves as an organon of discovery. It is the only known scientific way of answering the question: How has the present-day system of Animate Nature come into being?

All the facts of botany and zoology may be used as evidences of evolution if we know enough about them, and yet their cumulative weight cannot be called strictly demonstrative. This much may be said, however, that both past and present become uncomfortably magical unless the evolutionary formulation be true. For how otherwise can we account, for instance, for the twisting and moulding of the same fundamental materials, notably bones and muscles, to make the fore-limb of a frog, the paddle of a turtle, the wing of a bird, the fore-leg of a horse, the flipper of a whale, the wing of a bat, or the arm of man? Can these homologies, this 'adherence to type' be understood save as indicating blood-relationship? How can we interpret the numerous useless vestigial structures in higher animals except as the dwindled relics of structures which were well-developed and functional in ancestral forms? The two sets of teeth in whalebone whales that never cut the gum, the deeply buried representative of hip girdle and hind leg in many Cetaceans, the hint of a third eyelid in man, are they conceivable except as historical vestiges, like the unsounded letters in many words, to use Darwin's comparison, or like the functionless buttons and buttonholes in our clothing? What apart from evolution can be the significance of the classifiability of organisms into varieties, species, genera, families, orders, classes, and phyla, of the 'connecting links' and 'synthetic types'? There seems no alternative between a miraculous world and an evolved one when we learn that the blood of a horse mingles harmoniously with that of an ass, and a hare's with a rabbit's, while man's blood added to any of them produces destruction of corpuscles. Blood-relationship is not a metaphor; its degree can be measured by a precipitate. We cannot visit the exhibitions of pigeons and poultry, of cats and canaries, of cabbages and chrysanthemums, of roses and apples, without asking: If Man has utilised organic variability to such purpose in a short time, what may not Nature have effected in the course of many millions of years? The rock record discloses the lineage of horse and elephant, crocodile and ammonite; it yields missing links to the sceptic; it shows us above all that, as age succeeded age, there was an emergence of nobler and nobler forms of life.

We remember, too, how Darwin on his 'Beagle' voyage, which discovered a new world, was struck by the simple fact that the modern distribution of those strange survivals, the sloths and armadillos, was centred round the burying-ground of the huge majority of their race. And clinching the whole argument, though we admit that it is only presumptive, there is the embryological evidence. The embryos of reptiles, birds, and mammals travel in their development for a considerable distance along the same road, or along approximately parallel roads, before they diverge, each on its own path; and in the making of organs there is many a bend of the road very puzzling except on the theory that the individual development is to some extent a re-treading of the track which the race blazed in its evolution. What can be made of the gill-clefts in the region of the neck in embryo reptiles, birds, and mammals, of no use for breathing, of no use at all save the first, which becomes the Eustachian tube, unless they be genuine relics of aquatic ancestors breathing in fish-fashion?

The strength of the evolution-theory as a modal formula of becoming is that it works well. It is a useful organon of research. It clears things up and prompts discovery. There is no other scientific formulation in the field. But it is not without elements of weakness. In the first place, we are remarkably ignorant in regard to the pedigree of some of the most important types, such as backboned animals. This is not to be wondered at, because so many of the great branches had begun to diverge from the genealogical tree in very ancient times, of which there is relatively little fossil-record. In regard to some more recent originations, such as elephants and horses, the pedigree is very well known.

In the second place, apart from the general formula, little light has been thrown on the factors at work in the establishment of most of the great new departures. How little we can say of the factors operative in the emergence of Birds from a Saurian stock or of Man from a Primate stock! Some people talk as if they believed that one had only to mutter the word 'Evolution' for difficulties to disappear.

In the third place, there is the general and central difficulty that we know so very little—serious ætiology practically dates from Darwin—in regard to the causes of variation itself, on which all evolution depends.

§ 7. *Difficulties in the Way of Concrete Evolution Theory Lead to Hypotheses of Transcendental Underpinning.*

The difficulty of giving a concrete account of the evolution of a phylum such as Vertebrates, or of an organ like the eye, or of a phenomenon like migration, is great; but it will probably disappear as knowledge grows. It must be remembered, however, that the difficulty led so distinguished a pioneer as Alfred Russel Wallace and some others with him to postulate the operation of spiritual influxes at particularly critical stages in the evolution, as in the origin of man's mathematical, musical, and artistic faculties, or in the introduction of consciousness, or in the emergence of organisms themselves. Wallace spoke of "different degrees of spiritual influx", as it were welling up from "an unseen universe—a world of spirit, to which the world of matter is altogether subordinate". . . . "A change in essential nature (due, probably, to causes of a higher order than those of the material universe) took place at the several stages of progress which I have indicated; a change which may be none the less real because absolutely imperceptible at its point of origin, as is the change that takes place in the curve in which a body is moving when the application of some new force causes the curve to be slightly altered" (*Darwinism*, 1889, p. 476).

Without confining ourselves to Wallace's position, let us inquire into the theories of spiritual influx. (*a*) In some forms they amount to a premature abandonment of the scientific mode of attacking the problem. For scientific formulation proposes to work with verifiable factors, and that cannot be said of spiritual influxes operating in organic evolution. We see reason for attaching much importance to the influence of mind in evolution,—a capacity for behaviour of which we cannot give a protoplasmic account, but this is amenable to experimentation and to verification by competent observers. (*b*) A spiritual influx theory is apt to be associated with a fanciful dualism, implying two worlds, one of which only occasionally intrudes effectively into the other. This means an abandonment of the idea of continuity of process. There are some who regard the biologist's conviction of a process without gaps as an illusion, who frankly avow their belief in extrinsic factors of another order than those admitting of scientific study, which now and again move organisms like puppets in a show; and Wallace spoke of "a change in essential nature (due, probably, to causes of a higher order than those of the material universe)". This view may seem to us to break the law of parsimony, but it would be difficult to prove it false. What we cannot accept, however, is Wallace's assurance that on his theory the process of evolution was none the less continuous. The Ice Age, he said, introduced new factors into the process of earth-sculpture, but there was no discontinuity. But 'spiritual influxes' do not seem to be as amenable to scientific treatment as glacial influences have been. Wallace apparently thought of the material universe being underpinned throughout by a spiritual universe, and we have no right to object to that, but what the scientific mind recoils from is the suggestion that a spiritual influx occasionally operates dramatically, helping the organism over difficult stiles. (*c*) It is possible that some of those who hold by a 'spiritual influx' theory mean little more than those who are dissatisfied with a mechanistic evolutionism. They recognise that more is *involved* in the *evolving* organism than is recognised by those who think that it can be exhaustively summed up in terms of matter and motion. In mankind we are sure that ideas count as a *vera causa* in evolution; the question is how far biologists can discern in animal evolution psychical factors that can be tested and experimented with by appropriate methods. One of the protagonists of the *mechanistic* interpretation of man declares, without seeing the humour of it, that he can demonstrate the physiological effects of an *anticipation* of an operation. A mechanistic anticipation!

In seeking some reconciliation of religious conviction and the results of science various attempts have been made, like Wallace's, "to get past the scientific position without the danger of being taken prisoner". In regard to the worst of these we quote Prof. G. J. Blewett (1907, p. 53):

"One of these attempts to 'get past the scientific position' is so fundamentally bad as to deserve special mention—the endeavour to justify belief in God by seeking to find gaps in the continuity of nature. It is true that a God thus made manifest—made manifest not by the greatness and harmony of nature, not by its abiding law and continuous order, but by its rents and gaps—would be no worthy object of religious devotion. But that is only the beginning of the matter. Once you shatter the continuity of nature, you shatter more than Materialism. You shatter the possibility of all science whatever. You open up the gulf of universal scepticism, and Materialism disappears in it, it is true, but along with it will disappear Theism and Theology and the rational basis for every sort of religion except two, between which men will continue to choose according to their individual dispositions—Stoicism (as a practical temper, not as a philosophy) and Epicureanism."

§ 8. *In What Sense Is Organic Evolution Continuous?*

By continuity in the process of organic evolution the biologist does not mean that there are no breaks, no leaps, no brusque novelties. For there is a growing belief in the importance of transilient variations or mutations. These appear suddenly, without intergrades connecting them to the parents. The Proteus leaps as well as creeps. But though Professor Bateson calls them discontinuous variations, there is no discontinuity in their emergence any more than there is in the metamorphosis of a caterpillar into a butterfly. By continuity in evolution the biologist means that there are no gaps, no intrusions. As Prof. W. R. Sorley puts it (Proc. Brit. Acad., IV., 1909, p. 5) : "Each stage in the process with all that it contains must find its explanation within the universe and not in something outside." One may say more, that each stage is the outcome of what precedes. Whether we think of the evolution of Animate Nature as a whole, or of particular individualities within it, there is a twofold continuity to be recognised. There is the flesh-and-blood linkage, the genetic 'enchaînement des êtres', the continuous succession of immortal germ-cells in spite of transformation of species here and extinction there and blind alleys somewhere else. But there is also a continuity in the external staging, in the extra-organismal systematisations, in what we have called the web of life. This is of extraordinary importance in the case of mankind; naturalists have not allowed enough for it in the case of animal and plant organisms.

But we must not exaggerate the idea of continuity. Both as regards the organism and its environment of inter-relations we have to recognise that with all the continuity there is continual change. Birds are continuous with reptiles, but not continuations of them, and at the time of their evolution there was a correlated change in the genesis of the earth which opened to birds a new world indeed.

While birds are very different from reptiles, indubitable new ideas, it is possible to imagine how a fore-limb could become a wing and a scale a feather, and that sort of discontinuity is familiar to all students of evolution. On the other hand, it is certain, from centuries of failures, that by no jugglery of words can we account for thinking in terms of matter and motion. Therefore the alternatives (1) to regard the scientific belief in evolution as in part at least an illusion, since what comes later, *e.g.,* thinking, is distinct in kind from what comes earlier; or (2) to suppose that the lowest animals are potentially psychical; with, as Sir Francis Darwin puts it (Presidential Address, British Association, 1908), "faint copy of all we know as consciousness in ourselves". The first position is not easy, for the evolutionary explanation is practically proved along anatomical and physiological lines; the second position is not easy, for the 'faint copy' becomes faint indeed when we pass to the simplest organisms.

Here again we venture to quote from Professor Blewett's *Study of Nature and the Vision of God* (1907, p. 53):

"In insisting upon the continuity of nature, men of science have been better theologians than the theologians themselves. If God exists at all He is the God of all nature and of every natural law. There are no gaps in His workmanship, no breaches of continuity in His activity. All nature is an activity of His, and every natural law a principle of that activity. If the theologians would be true to theology, what they have to do is to protest, not against the principle of continuity, but against too narrow a reading of it, and too narrow an application of it to reality. The principle of continuity is unworthily treated if it is limited to certain physical and chemical processes. The true field of the principle of continuity is the total history in time, the total evolution, of the universe. And so viewed, it is simply one way of apprehending the essential rationality of God and of the divine action in nature and in history."

§ 8. *In What Sense Is Organic Evolution Progressive?*

If increasing differentiation and integration is progress, then Organic Evolution is most certainly progressive. Not only when envisaged as a whole, but when attention is focussed on particular lines, Animate Nature exhibits, as age succeeds age, an increasing differentiation or complexifying and an increasing integration or correlating. A locomotive of the twentieth century shows, when compared with Stephenson's engine, a much greater division of labour and specialisation of parts; it also shows a much greater harmony of action and controllability. The same is revealed in organic nature, when we compare an oak tree with a mushroom, or a bird with a sponge. As age has succeeded age, life has been in the main creeping upwards. It is not that we naïvely rank as progress any change that makes a creature liker ourselves; there is a discernible standard with objectively verifiable features—increasing differentiation and integration—in a word *organisation.*

Three admissions must be made. (1) It is plain that evolution may be down as well as up, and that the gates of parasitism and other facile slopes of degenerate life are always open. The tapeworm in its inglorious ease is as much an outcome of evolution as the lark at heaven's gate. It is a misunderstanding to suppose that a result necessarily acquires value, in any human sense, by being the outcome of evolution, or that evolution is synonymous with progress. (2) There are many corners where organisms seem to have run riot in exuberant complication, often extraordinarily beautiful, but without further significance so far as we have yet been able to discern. We shall return to the interesting fact that these instances of exuberance are sometimes in conditions of life that are peculiarly secure, where the pruning knife of Natural Selection is in abeyance. (3) Some of the most remarkable achievements of evolution have passed away in their prime without leaving direct descendants. It is probable, however, as we shall illustrate later on, that the distinctive gains of these lost races are, sometimes at least, conserved along collateral lines.

To be chastised out of our mind is the smug conceit that all evolutionary change, especially that in which Man is concerned, is *ipso facto* progressive, whatever that may mean. Perhaps the lightest whip is best: "Organic life, we are told, has developed gradually from the protozoon to the philosopher, and this development, we are assured, is indubitably an advance. Unfortunately it is the philosopher, not the protozoon, who gives us this assurance, and we can have no security that the impartial outsider would agree with the philosopher's self-complacent assumption" (Bertrand Russell on the "Philosophy of Evolution" in *Mysticism and Logic,* 1918). A sense of humour forbids any retort to so true a jest.

These admissions notwithstanding, the large fact is certain that on the whole there has been for many millions of years progressive differentiation and integration along diverse lines, an increasingly complex and masterly behaviour, a growing emancipation of mind and an approximation to personality. This is the largest fact to be borne in mind in our interpretation of evolution. The process has been on the whole progressive. With Lotze we hear "an onward-advancing melody".

We certainly miss part of the impressiveness and suggestiveness of the evolutionary process if we do not realise its solidarity. It concerns a developing system, like a great organism, in which the exuberance of one part and the tardiness of another cannot be said to disturb the balanced movement of the whole. Twigs shoot forth out of due time and are broken off; huge branches of extraordinary magnificence (like the lost races of Giant Reptiles) fall crashing to the ground, but the tree lives on in order and balance. And if we consider not our biosphere, merely, but the whole cosmic system that we know, we get the same impression. Evolution is based on order and works out in order. "A certain unity manifests itself then in the Cosmos, a unity comparable to that which the development of an organism reveals" (Joussain, 1912, p. 185).

Without losing sight of real differences we may believe in a continuity of evolutionary process from inorganic genesis to human history, but it must be confessed that there is a good deal of scientific faith implied. Philosophically it seems fair to say that if organic evolution is traced back into inorganic genesis, it must also be traced forward into human history, and the process regarded, as far as we can, as a whole. It is a misleading abstraction "to treat the world of nature as a fact complete in itself, a system finished without man. . . . Man is organic to nature, and nature is organic to man. It is a false abstraction to try to take the world apart from the central fact in which it so obviously finds expression" (Pringle-Pattison, 1917, p. 177).

SUMMARY.

The scientific theory of evolution has suffered from a scarcity of facts and a plethora of words, yet also from a dearth of words. For the term 'evolution' is used with fallacious elasticity for processes of becoming in very different fields. The use of differential terms for the three great orders of facts may be suggested. In the domain of the inorganic we study the *genesis* of the solar system, of a range of mountains, or of precious stones. In the realm of organisms we study the *development* (or ontogeny) of the individual and the *evolution* (or phylogeny) of the species or race. In the kingdom of man we study the *history* of institutions, social activities, and the like.

Organic evolution differs from inorganic genesis: since organism transcends mechanism; since organismal variation is quite different from the ubiquitous inorganic flux (which has its analogue in ageing, dying, re-incorporation, etc.); and since inorganic genesis, as in the making of a star, has its analogue in the individual development of the organism, not in racial evolution, where much shares in the process of becoming that does not figure in the final result.

Organic evolution differs from the history of human societary forms: because social variations are not restricted to the germplasm; because the extra-organismal or social heritage bulks so largely; and because there is not in the realm of organisms more than a dim adumbration of deliberate selection, towards a social ideal, by means of social sifting-organisations. Yet there are quaint forms of social organisation on the instinctive line which command admiration, though, for ethical reasons, Man cannot take any imitative advantage of their subtlety.

Organic evolution is a continuous natural process of racial change in a definite direction, whereby distinctively new individualities arise, take root and flourish, alongside of, or in place of the originative stock. In a general way, it means that the present, with its fine fauna and flora and the inter-relations of these, is the product of the past and the promise of the future.

It is necessary, however, to consider the view that evolution may have been not synthetic complexifying, but analytic simplification, —by a removal of inhibitions which has allowed the original richness of endownment to express itself with increasing fulness. This view of evolution is open to several serious objections which show its untenability. In so far as the view means that there is nothing evolved which was not in kind originally involved, that there is nothing of lasting value in the end which was not present in kind in the beginning, it is acceptable. But Biology is justified in regarding evolution as a racial epigenesis.

The evolution-formula cannot be demonstrated like that of gravitation; it is acceptable because it fits and is never contradicted by facts. The so-called "evidences of evolution"—anatomical, embryological, palæontological, and so on—are multitudinous; but they are never more than presumptive. The real strength of the evolutionist's position is in the value of the theory as an organon. There is no other scientific formulation in the field. The weakness of the evolutionist's position is that he remains very ignorant as to the pedigree of many of the most important types, such as Vertebrates; as to the factors leading to the establishment of great new departures, such as birds or men; and as to the causes of variation itself. But the inquiry is young.

The difficulties in the way of concrete evolution-theory, which will probably disappear as knowledge grows, have prompted the suggestion made by Alfred Russel Wallace and others that special spiritual influxes have operated at various critical stages in the process of becoming. This means a premature abandonment of the scientific problem, which proposes to work with verifiable factors; it suggests a fanciful dualism of two worlds, one of which occasionally intrudes effectively into the other; it gives up the idea of continuity of process. It is not to be identified with the conviction that more is involved in evolving organisms than is recognised by those who insist on restricting their formulation to mechanistic terms.

Evolution is continuous in the sense that it is a process without gaps. But it is not without steps, for discontinuous variations or mutations seem to be important realities. What is meant by the continuity of evolution is that each stage in the process has its full precondition (we do not say interpretation) in what precedes. There is a flesh-and-blood continuity of lineage ('enchaînement des êtres'), and there is also continuity in the extra-organismal order which includes the established system of inter-relations.

In regard to the progressiveness of Animate Evolution, three admissions must first be made. There have been many retrogressive lines, notably in adaptation to parasitism and sedentary life. There are also many corners where organisms seem to have run riot in exuberant complication, often extraordinarily beautiful, but without further significance that we can discern. Some of the most striking achievements of evolution, such as the flying dragons, have passed away in their prime without leaving direct descendants. It is probable, however, that the distinctive gains of these lost races may have been conserved on collateral lines.

These admissions notwithstanding, the large fact is certain that on the whole there has been progressive differentiation and integration along diverse lines, an increase in the complexity and masterfulness of behaviour, a growing emancipation of mind, and an approximation to personality. This is the fundamental fact to be borne in mind in our *interpretation* of evolution.

LECTURE XII.

GREAT STEPS IN ORGANIC EVOLUTION.

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§ 1. *The Origin of Organisms upon the Earth.* § 2. *The Nature of the First Organisms.* § 3. *Establishment of Diverse Types of Cellular Organisation.* § 4. *The Divergence of Green Plants.* § 5. *The Making of Bodies.* § 6. *The Divergence of the Sexes.* § 7. *Progressive Differentiations and Integrations.* § 8. *Rise and Progress of Backboned Animals.* § 9. *The Ascent of Man.* § 10. *General Impressions of Animate Evolution.*

The largest and most overwhelming idea in all science is that the system of Nature in all its complexity, intricacy, multitudinousness, and harmony has come to be as it is from apparently simple beginnings—from something like a nebula if we go back to inorganic genesis, from a crowd of invisible microbes if we begin with the primordial organisms on the cooling earth. We say the word evolution so often that we are apt to get dull to the overpowering grandeur and undeniable mysteriousness of the process. It may not be altogether unprofitable to attempt the impossible,—a short review of the great achievements.

§ 1. *The Origin of Organisms upon the Earth.*

As every one knows, there was a time when the temperature of our earth was beyond the endurance even of the mythical salamander. It was far too high to admit of the existence of forms of life like those we know, or can even imagine, and we need not speculate about others. There was a time, therefore, when living organisms began to be upon the earth.

Whether germs of living organisms reached terrestrial shores from elsewhere, borne in the crevices of a meteorite or wafted by light waves amid cosmic dust, or whether living organisms may have evolved from not-living material, *e.g.,* from some colloidal carbonaceous slime in which ferments were operative, we do not know. No hypothesis of abiogenesis (*i.e.,* of the origin of the living from the not-living) has yet been suggested that can be accepted with easy-going satisfaction. Whether we start with an inorganic colloid able to utilise solar energy, or with formaldehyde generated by lightning flashes through moist air, or with the cyanogen radicle formed in incandescent materials, difficulties abound. It is not of much avail to point to the achievements of the synthetic chemist unless we can indicate in Inorganic Nature some analogous agency able to pick and choose, combine and eliminate. On the other hand, one is not inclined to lay much stress on the fact that there has not been as yet effected in the chemical laboratories any synthesis of natural proteins, the substances which always form an important part of the physical basis of life; for who would have suspected a few years ago that we should now be using artificially compounded indigo and salicylic acid? More important is it to remember that there is not to be found in natural conditions anything like living matter (or protoplasm) except as organised in the form of organisms or pieces of organisms; that we do not know of a 'living substance' as we know of, say, albumen; that the problem is the origin of *organisms.*

As regards the origin of protoplasm, "the physical basis of life", as Huxley called it, there is not at present much that can be profitably said. In a letter to Alfred Russel Wallace, Sir W. T. Thiselton-Dyer expressed his sense of the extreme difficulty of the problem. "We cannot form the slightest idea how protoplasm came into existence." It is not a mere substance; it is an organisation, and when we speak of the complex substances that the chemist makes we should remember that he usually does so by complicated processes. "Protoplasm appears to be able to manufacture them straight off in a way of which the chemist cannot form the slightest conception" (quoted in *Alfred Russel Wallace: Letters and Reminiscences.* By James Marchant. 1916. Vol. II., pp. 95-8).

If in the future it should become easier for a biologist to say that simple organisms probably evolved naturally from non-living materials, from some colloidal carbonaceous slime activated by ferments, or otherwise; if it should be found possible to make in the laboratory a microscopic material system which lived; what difference would it make to our general thinking save that the domain of the inorganic would appear more continuous than before with the realm of organisms? If it should become easier in the course of this century for a biologist to say that living creatures were probably born of the dust of the earth and the dew of heaven, with the sun shining on both, then would all the groaning and travailing of the inorganic appear more intelligible. Then also it would be clearer than ever that there was in the beginning more than could meet the eye, more than could be summed up in the laws of matter and motion. For no one can conjure 'mind' out of 'matter', even if he invoke 'Evolution' many times.

In ancient days fire was lit from fire, and it was naturally a sacred duty to keep the fire burning. Before the discovery of electro-magnetism, magnets were made from magnets. And until recently crystals were obtained in a crystallisable solution only by the introduction of a nucleus of crystallisation. Thus melted salol, protected from crystals of any kind, remains liquid indefinitely in a closed tube. If it be touched with a platinum wire that has been in contact with solid salol, crystallisation sets in, because a nucleus has been introduced. If the wire be heated first its introduction is without effect. But in 1867, as Professor Dastre (1911) points out, crystals of glycerine appeared spontaneously in glycerine, and have since been spread throughout Europe. No one knows the circumstances which determined their formation, and if they became extinct, as might readily happen, no one knows how to produce them again. In the same way,—this is Professor Dastre's pertinent argument,—the fact that within our knowledge living organism always springs from similar living organism, and that no spontaneous generation of any microbe has ever been demonstrated in any culture-medium, does not warrant us in making a dogma of *omne vivum e vivo.*

Prof. Lloyd Morgan's position in regard to the origin of living organisms is one that commends itself. "Of protoplasm we may likewise say that under certain conditions, at present unknown, it appeared. Those who would concentrate the mystery of existence on the pin-point of the genesis of protoplasm do violence alike to philosophy and to religion. Those who would single out from among the multitudinous differentiations of an evolving universe this alone for special interposition would seem to do little honour to the Divinity they profess to serve. Theodore Parker gave expression to a broader and more reverent theology when he said: "The universe, broad and deep and high, is a handful of dust which God enchants. He is the mysterious magic which possesses "—not protoplasm merely, but—" the world" (*Interpretation of Nature,* p. 77).

§ 2. *The Nature of the First Organisms.*

Regarding the first organisms we know nothing, but biologists who have given a lifetime to the study of cells and simple creatures are able to make certain useful statements. It is quite certain that most of the Protozoa, even everyday forms like Amœbæ and Slipper Animalcules, are the results of long-continued evolution. We may call them unicellular or non-cellular, but they are masterpieces of complexity. The problematical first organisms were not like them. A minute Infusorian called Bellerophon (Penard, 1914) shows on each side a number of prominences like guns projecting from port-holes. Minute cysts may be seen travelling up into these prominences, and there, when occasion demands, they explode into offensive threads. It is plain that Bellerophon is not a *simple* organism, not a Protozoon in the literal sense.

The late Prof. E. A. Minchin, an expert Protistologist, suggested that the earliest living beings were very minute, possibly ultra-microscopic, units or biococci of chromatin,—the protein material that is characteristic of the nuclei of all cells. Suppose a firm envelope to be formed around one of these chromatin globules, and behold a bacterial type of organism. Suppose the chromatin globules to increase in number and then to show some complexity of arrangement, and suppose a non-chromatinic ground-substance (cytoplasm) to accumulate between them and the envelope, and behold a primitive vegetable unit.

But suppose that around the chromatin granules there was formed an enveloping matrix of restless semifluid substance, rapidly discharging what explosives it got a hold of, in other words living nearly up to its income, and exhibiting streaming outflowings and amœboid movements. *This was the first animal,* and it preyed on smaller organisms. When the chromatin granules concentrated into and were integrated into a definite nucleus—an organised kernel—the first true cell was formed. The details are all uncertain, but it is probably safe to say that a long journey had to be travelled before even the first cell appeared. It need hardly be said that the numerous suppositions made in this paragraph have a factual basis in existing organisms of low degree.

§ 3. *Establishment of Diverse Types of Cellular Organisation.*

The next great series of steps had to do with the establishment of a variety of types of cellular organisation, besides the bacterial and amœboid already referred to. Some active forms evolved cilia and flagella; some sluggish forms evolved protective cysts, adapted to unpropitious circumstances and times; some creeping forms got a skeleton which made them more coherent; others were adapted to flotation; and so on endlessly. A luminous idea was long ago developed by Prof. Patrick Geddes in his conception of the 'cell-cycle', that there are three great pathways of cellular evolution—the very active Infusorian-line, the very sluggish Sporozoon-line, and the median compromise of the Amœboid-line. These three lines correspond to the three physiological régimes of lavish expenditure or 'living dangerously', of preponderant saving or a life of ease, and of a balance between these extremes. The cells of higher animals may be in part classified on these three lines—ciliated, encysted, amœboid; and there is often, even in man, a transition from one line to another, just as in the life-history of the very simplest Protists, which pass through a cycle of phases without accentuating any one. It is significant that we should see the main physiological possibilities blocked out so early.

We must repeat that if we are asked how there could be in the Primordial Organisms all the promise and potentiality of bee-kind, bird-kind, mankind, we cannot answer save to say that the question is not rightly put. But what we may ask is how the Primordial Organisms contained the promise and potentiality of the next stage in the Systema Naturæ, and it is not so difficult to answer that question.

§ 4. *The Divergence of Green Plants.*

One of the early great events was the emergence of green plants, possibly from an Infusorian stock. Either they or their ancestors had built up chlorophyll, which is probably the most important single substance in the world, for it is in association with this green pigment that the sunlight becomes available to living matter as a source of energy in building up organic compounds. The divergence of plants and animals was one of the great cleavages in organic nature, —distinguishing those that feed at a low chemical level from those that feed high, the manufacturers of explosives from those that fire them, the savers from the spenders, the predominantly sedentary from the predominantly locomotor, the anabolists from the katabolists, the sleepers from the wakeful, the captives from the free. The contrast between plant and animal is one of the fundamental dichotomies; parallel dichotomies recur many times in the story of evolution,—on to the phlegmatic, imperturbable, fatalistic, hypokinetic type of man and his energetic, excitable, rebellious, hyper-kinetic counterpart.

It is beyond our present scope to follow the plant line of evolution, which went on simultaneously with that of the animal world, the two often intersecting, indeed intertwining. Perhaps the most striking general impression is that of a succession of dominant groups, each of great excellence, each attaining a climax and supremacy and then yielding to another. Thus the gigantic Club Mosses and Horsetails of the Carboniferous forests, to which Man owes so much, yielded to Cycad-like forms and passed into relative insignificance, with little more than pigmy representatives to-day; thus the Cycadophytes in their turn yielded to Flowering Plants.

§ 5. *The Making of Bodies.*

It was an epoch-making step in organic evolution when 'bodies' began to be, that is to say when the transition was made from the unicellular to the multicellular grade of organisation. In some Protozoa the division of the unit is not followed by actual separation, the daughter-units remain associated instead of drifting apart, and thus, coherent colonies arise. In some such way multicellular organisms may have been evolved. It was not increase of size that was primarily important, for many a Rotifer with a thousand cells is smaller than a unicellular Protozoon, such as the Noctiluca which causes much of the phosphorescence of our summer seas. Nor was the step primarily one of increased complexity, either of structure or of activity, for many unicellular organisms are far more complex in plasmic and in skeletal architecture and in their behaviour than are, for instance, the fresh-water polyps, built up as these are of thousands of cells. The establishment of a body was one of the mysterious big lifts in evolution, rising to a new grade of organisation. More scope was given for specialisation of function, and indirectly for increase in size, since free-living single cells cannot grow large except in very peaceful surroundings. Getting a body made great increase in size possible, which, other things equal, counts for something in a rough and callous physical environment, especially if anything aggressive is to be done. One advantage is the possibility of storing energy for vigorous assault on the environment. Another advantage is the possibility of resting and of lying low. Capitalisation has always meant much in evolution.

But the nemesis of gaining a body was liability to natural death,—a liability proportionate to the complexity of the bodily framework. For the more differentiation there is in the colloid substratum in which the chemical processes take place, the more difficult is it for processes of repair and rejuvenescence to counteract that accumulation of wear and tear results which spells senescence (see Child, *Senescence and Rejuvenescence,* Chicago, 1915).

§ 6. *The Divergence of the Sexes.*

Another step with far-reaching consequences was the evolution of male and female multicellular individuals within the same species, the two being complementary in the continuance of the race. The first hints of this were among the Protozoa, but these are probably on a side-track. The big fact was the origin of two dimorphic types within the species, a dichotomy like that between plants and animals, probably expressing alternative rates or rhythms of biochemical routine, and culminating in the contrasts between peacock and peahen, ruff and reeve, stag and hind, man and woman. Sexual reproduction meant much in immediate reward. It meant a more economical means of continuing the race; it meant a device for securing the persistence of a successful constitution and for screening the offspring from disadvantageous dints made on the parent's body; it meant more opportunities for re-arrangements of the hereditary items at the beginning of each new life. But the separation of sperm-producers or males and egg-producers or females, differing deeply in constitution, would also tend to increase the possible range of cross-fertilisation, which is often advantageous, and would permit of a very profitable division of labour between the two parents in their relations to the offspring. For the masculine constitution has rarely proved adaptable to mothering. But at a great distance the divergence attained another justification, for sex-dimorphism afforded a basis for love, becoming a liberator and an educator of emotions which have enriched and ennobled the lives of many creatures. It is surely a fact of encouragement to man that there are in the evolution of sex many instances of the sublimation of what was, to start with, somewhat rough and crude, into what, in some birds for instance, it is difficult not to regard as a fine affection.

§ 7. *Progressive Differentiations and Integrations.*

A multitude of evolutionary steps of great interest must be summed up in the phrase progressive differentiation. Tissues begin in sponges, organs in the stinging animals or Cœlenterates. As we ascend the series we see organ added to organ in a way that suggests inexhaustible resources.

The radial symmetry of sponge and zoophyte, jellyfish and coral, well enough suited for a sedentary or for a drifting life, was replaced among the worms by bilateral symmetry, suited for more strenuous life, such as that involved in chasing victims, avoiding enemies, pursuing mates, and shepherding the offspring. This was another literally epoch-making step; it was the beginning of our knowing our right hand from our left. It meant a distinction between head and tail, right and left; it was the beginning of head-brains and cephalisation.

This opened up great possibilities of integration, which means more perfect unity and control, especially through the nervous system. Differentiation may be compared to the extension of an empire and to the complex division of labour that is established in different parts of it; integration is the binding of the whole into harmonious federation and unified control.

This is not the place to follow the long succession of achievements in differentiation and integration which mark organic evolution, but we shall simply mention a few:—an open food-canal, a body-cavity or cœlom between it and the body-wall, striated or swiftly-contracting muscle, a fluid tissue such as blood or lymph, circulatory organs for keeping this in movement and thus distributing throughout the body digested food and oxygen and collecting waste, oxygen-capturing pigments such as hæmoglobin, a segmented body as in earthworms, a renewable external armour as in crustaceans, muscular appendages unjointed to start with and by and by jointed, specialised sense-organs such as eyes and balancers and chemo-ceptors, improved respiratory arrangements reaching extraordinary perfection among insects where the blood hardly becomes impure, delicate adjustments for filtering out the poisonous nitrogenous waste of the body, for checkmating intrusive parasites, irritants, and poisons, for dealing with frequently recurrent injuries such as lost arms in starfishes and broken legs in crabs, and so on through a long list.

We can only allude to the establishment of the leading types of architecture which are represented by the various series of Invertebrates or backboneless animals. Besides and beyond the sponges and Cœlenterates already spoken of, we have to deal with a perplexing variety of worm-types; with the higher segmented worms or Annelids, probably leading on to Vertebrates; with the starfishes, sea-urchins, and the like forming the series of Echinoderms; with the jointed-footed Arthropods, such as crustaceans, insects, and spiders, in which instinctive behaviour reaches its climax; with the unsegmented limbless Molluscs, such as bivalves, snails, and cuttles; and many a smaller group besides.

To what purpose such enumeration? Simply that we must bear in mind the fact that millions of years are spent in the fashioning of minutiæ of perfection in types which are certainly not near the highway of evolution that led to backboned animals and eventually to man. Nothing is too remote, too minute, too trivial—everything must be finished and refined. Though it take a million years to make an Argonaut, there is no hurry.

§ 8. *Rise and Progress of Backboned Animals.*

But a step of great magnitude among many that were eventful was the origin of backboned animals or Vertebrates, which perhaps emerged from an Annelid stock. The origin of Vertebrates meant an independent start on a new line of more masterful life. A dominant feature was the establishment of a relatively large brain protected by a skull and of a long spinal cord protected by the backbone. For there were in this new type of nervous system fresh possibilities of elaborate and subtle integration, of registering experience and experiments on a large scale, yet without interfering with openness of mind, and probably of a richer and freer stream of inner life. It was in Vertebrates first that bone made its appearance, and formed a living internal skeleton pervading the whole body. This contributed not a little to integration. In the establishment of numerous glands of internal secretion, whose hormones or regulative substances are distributed throughout the body, a chemical integration began to operate or to operate on a larger scale (for we know very little of such organs of internal secretion in backboneless animals). It is difficult to exaggerate the importance of these organs in backboned animals, for they are regulatory arrangements which secure smooth working. In one way they make the organism more automatic; in another way they set it free for higher issues. How much is our peace of mind dependent on the insignificant looking speed-regulator, which we call the thyroid gland, or on what the adrenals do in the way of rapidly altering the blood-pressure.

Skulls began with the hags and lampreys—simple gristly brain-boxes to start with; jaws and paired fins, scales and typical gills with the true fishes; digits, true lungs, vocal cords, and a mobile tongue—what a list of acquisitions—with the phlegmatic amphibians; the ante-natal robes (or fœtal membranes) known as amnion and allantois with the reptiles; a four-chambered heart with the crocodilians; warm-bloodedness or keeping the temperature of the body approximately constant with birds and mammals, which also show an enormous advance in brain development,—the big-brain type at length coming to its own. The usually prolonged ante-natal connection between mother and offspring began with the placental mammals; it implied an intimate living together or symbiosis of parent and child that has been of far-reaching importance.

We must remember also how some amphibians achieved what a few fishes essayed, getting foothold on dry land. Most of the amphibian pioneers have to return to the water in their breeding and early development, and the possession of dry land must be put to the credit of reptiles, and associated with what seems at first sight a mere internal detail,—the development of an ante-natal robe that secures breathing through the egg-shell. And just as amphibians mark the transition from water to dry land, which the reptiles perfected, so the extinct flying dragons or pterodactyls pointed from a great distance to that mastery of the air which birds and bats perfected,—each type, however, it is interesting to notice, presenting a different solution of the problem of flight.

As we have already seen, the great structural advances are associated with progressiveness of behaviour. Many an infusorian has a very complex life and orders its goings very perfectly, but the range is obviously narrower than that of a spider and the resources are fewer. The behaviour of ants and bees is very complex and on the instinctive line very effective, we may almost say, unsurpassable. But the range is narrower than that of a dog, and the resources are fewer. It is in the big-brained birds and mammals that we find the most convincing evidence of an inner mental life of subjective experimenting, which we call in ourselves perceptual inference or intelligence. Very interesting also is the fact that as an organism attains to more or less intelligent mastery of its environment, it is able to practise reproductive economy. With heightened individuation there is associated lessened reproductivity. There are fewer offspring, which might be racially dangerous were there not a correlated increase of parental care which implies less juvenile mortality. If we read the story aright, the individual counts increasingly, and psychical linkages bind parents and offspring, and kin to kin.

§ 9. *The Ascent of Man.*

Finally, to bring our breathless survey to its climax, there appeared in the Early Eocene age, perhaps three million years ago, an arboreal race of mammals—the Primates—differentiated from other orders in digits and teeth, skull and brain. From this stock there diverged New World Monkeys and Old World Monkeys, small apes and large apes, until at length there was left a much purified humanoid stem, which after giving off some relative failures eventually realised itself in the modern man stock—" the summit of the whole ".

§ 10. *General Impressions of Animate Evolution.*

If we try to sink detail and seize the general impression, the dominant one is that of the gradual increase of *organisation.* This takes varied forms. There is a great deal of structural complexity in organisms that is merely quantitative, but there is a combination of differentiation and integration that is qualitative. The architecture of Venus's Flower Basket (Euplectella) is very intricate, but it does not amount to much more than the endless repetition of a certain kind of scaffolding, where three flinty axes meet at right angles and are firmly warped together where they cross. But compare that kind of intricacy with man's cerebral cortex, which is the chief seat of intelligence. It covers, if spread out, about a foot and a half square and is said to consist of about 9,200,000,000 nerve-cells, which are intricately connected together. Apart from supporting tissue and blood-vessels, these cells and their processes would only occupy about a cubic inch and weigh 13 grammes, but they form the material theatre of our intellectual life, and it is practically impossible to exaggerate the complexity of interrelations,—a complexity on a different plane altogether from that of the Venus's Flower Basket. In the sea-urchin there is, as Aristotle knew, a quaint piece of intricate skeleton, the lantern, which has masticatory, respiratory, and actually locomotor functions. It is a very fine contrivance, which works very beautifully; it consists of twenty-five or more different calcareous pieces and is worked by numerous muscles. But this sort of complexity, finely as it works, is on a relatively low plane compared with, say, our eye or ear—where organisation reaches its zenith.

But the organisation of structure which increases throughout evolution, except in cases of retrogression, is correlated with a complexifying of the internal economy of the body. The variety of internal activities increases, there are more different kinds of metabolism, the subtlety of correlation grows, the different processes work more perfectly into one another's hands. Small bodies near the kidneys secrete from part of their structure a potent substance called adrenalin which is passed into the blood. The amount of adrenalin in our blood is normally about one in 20,000,000 parts; but if we suffer from righteous anger the secretion of adrenalin rapidly increases and like magic prepares us for struggle, affecting the pressure and distribution of the blood, the vigour of the heart, the amount of sugar in the blood, the coagulability of the blood, the rapidity of recovery from fatigue, and so forth. In other words, the organism is subtly correlated not only for the everyday life of the peaceful citizen, but for emergencies when it becomes necessary to return to the ways of our ancestors.

Besides the progressive organisation of structure and the increasing intricacy and correlation there is a complexifying of the inter-relations of organisms. There is a long gamut from having an ocean to swim in and a homestead. The inter-relations of earthworms are not few, but the threads make much more intricate knots in the economy of birds. Many of the simpler animals are related to their environment —whether for food, oxygen, or anything else—in a very generalised way; but evolution has meant an increasing specialisation in the business of exploiting.

We must not forget that alongside of the organic evolution there proceeded an inorganic genesis, changes in which must have meant much to life. In his charming *Breath of Life,* John Burroughs has stated the idea picturesquely: "Does not man imply a cooler planet and a greater depth and refinement of soil than a dinosaur? Only after a certain house-cleaning and purification of the elements do higher forms appear; the vast accumulation of Silurian limestone must have hastened the age of fishes. The age of reptiles waited for the clearing of the air of the burden of carbon dioxide. The age of mammals awaited the deepening and enrichment of the soil and the stability of the earth's crust —who knows upon what physical conditions of the earth's elements the brain of man was dependent?"

Prof. H. F. Osborn has done good service in reminding evolutionists that their problem concerns four inter-acting complexes of energy:—the inorganic environment, the body of the organism, the 'heredity-germ', and the animate environment. How slow we are to learn, for instance, Weismann's lesson that the main steps of evolution are due to changes emerging *centrifugally* from the germ-cell, not, so far as we know, to changes impressed *centripetally* on the body. Yet the germinal variations require the aid of somatic functioning if they are to develop fully, and likewise the aid of encouragement from the inorganic environment. Furthermore the animate environment which forms part of the selective sieve is also in process of evolution. It is a correlated fourfold ('tetrakinetic') evolution that we have to deal with.

But the crowning feature of evolution is the increased masterfulness of behaviour. Even the very restricted brain development of bony fishes belongs to a different epoch from that of the medusæ under whose umbrella they sometimes shelter, and the otter is as far ahead of the fish as the fish is ahead of the medusa. It is not merely intricacy of behaviour; it is not merely effectiveness; there is plenty of both at very humble levels; the characteristic feature is more freedom, plasticity, and resourcefulness. As we shall afterwards see there is considerable reason for saying—though it is difficult exactly to prove it—that the outstanding fact about organic evolution is the increasing dominance of Mind. As we think of the advance from invisible micro-organisms to Mankind, we feel the grandeur of the process. The apparently simple beginnings, dimly discerned by us, have had large issues,—an extraordinarily fine, beautiful, and interesting fauna and flora, an intricate self-regulating and self-compensating system which has a moving equilibrium in spite of the continual breaking-down of parts. The eyes of Man's understanding have been darkened if he does not see something of the majesty of the great becoming.

We see that the length of time required for the evolutionary process has not been, so to speak, a consideration. Half-a-million years may be spent in the fashioning of a feather and longer in giving the horse his hoof. It is certain that the antiquity of man is enormously greater than even Lyell supposed. According to the calculations of experts like Keith and Sollas, it is probable that the human type diverged from the Anthropoid between two and three million years ago. But if it be, as many say, 800 million years since organisms began to spread upon the earth, then the duration of the biosphere has been to that of man as a long forenoon compared with one minute. What fills us with amazement is that so many of millions of years should have been spent, so to speak, in laying the foundations. Without rest, but certainly without haste, the process continued. Well might Bishop Butler say: "Men are impatient and for precipitating things; but the Author of nature appears deliberate throughout His operations, accomplishing His natural ends by slow successive steps." In modern terminology, "The Tempo of the Absolute is slow."

Impressive also is the fact that by-paths, leading nowhere in particular, are marked by the same finish as the great highways that approach such notable results as the bee-hive and the ant-hill, or the rookeries and the assemblies of cranes, or the troop of wild horses, or the village community. There are indeed many relatively simple organisms, like polyps, and some old-fashioned primitive types, like Peripatus, but the large fact is the detailed intricacy of the great majority of living creatures. With the category 'organism' we must associate a tendency to exquisite finish of complex structure. The living artist does not leave many creations in the sketch stage. "I believe," the poet said, "that everything is equally perfect."

It seems to us fair to say that the very broad foundations laid among backboneless animals and among the lower backboned animals like fishes, make the superstructure stable. Let us suppose for a moment—if we do not suppose it always—that the whole process of animate evolution is a coherent thought leading on to Man, who, limited as he is, has some capacity of intelligent appreciation, may it not be that the foundations were and are because without them the superstructure could not stand? That is a matter for interpretation, which is beyond science, and it introduces conceptions of values which are also beyond science. What we venture to emphasise is *the fact* that without the broad foundations the superstructure could not be. As biologists we do not say that a welter of water-fleas and the like came into being *in order that* there might be fishes, and fishes *in order that* there might be fishermen; what we do say is, that, as a matter of fact, the existence of fishes depends on that extraordinarily diversified, prolific, intricate, and beautiful fauna of minute organisms.

We have already referred to the puzzling disappearance of masterpieces, part of the explanation of which is that over-specialisation has its nemesis and that very successful organisms tend to a dangerous exuberance when they get away from the pruning shears of Natural Selection. But it was probably worth losing the giant reptiles to get birds and mammals in their stead. There is little evidence that big inventions once made have ever been lost.

But what must be dominant in our minds after a survey of the achievements of Animate Evolution is that the process has had its outcome in *personalities,* who have discerned something of its magnificent sweep, who are seeking to understand its factors, who are learning some of its lessons, who cannot rest until they interpret it—even though it be mistakenly.

SUMMARY.

The biggest fact of science is that the Systema Naturæ in all its complexity, intricacy, multitudinousness, and working harmony has come to be as it is from relatively simple beginnings and by successive achievements. By 'simple' is meant 'unevolved'—a nebula or a group of planetesimals, a zooglœa or a bunch of biococci.

Of the origin of the first organisms upon the earth we know nothing,—whether they came from elsewhere or were evolved from some not-living carbonaceous slime activated by ferments. Difficulties beset all the hypotheses of abiogenesis that have been as yet suggested; yet, on general grounds, it seems likely that abiogenesis occurred.

Of the nature of the first organisms we know nothing directly, but it is probable that they were of very minute size and much simpler than most of the Protozoa within the ordinary range of microscopic visibility. Minchin's suggestions leave us convinced that a long journey had to be travelled before the first cell appeared.

The next great step was the establishment of many distinct types of cellular organisation. Perhaps this was the time of the fundamental initiatives.

One of the early events was the emergence and the divergence of Green Plants,—a fundamentally important cleavage, without which the evolution of animals would not have been possible. The vegetative line of evolution is obviously off the main track.

An epoch-making step was the making of 'bodies', the transition from the unicellular or non-cellular grade of organisation to the multicellular. It opened the way for specialisation of function, for great increase in momentum, for storing energy, and so on, but it soon brought with it the nemesis of natural death.

Another step of far-reaching importance was the evolution of male and female multicellular individuals, differing in constitution, and complementary in the continuance of the race. This sex-

dimorphism or divergence had many organic advantages; it became also a liberator and educator of enriching emotions.

A multitude of evolutionary steps must be summed up in the phrase progressive differentiation and integration. Of unique importance was the replacement of radial symmetry by bilateral symmetry which led on to head-brains and cephalisation, and was the beginning of our knowing our right hand from our left. The zoologist discerns that the word epoch-making is not too large for such steps as the making of hæmoglobin, the invention of blood, the establishment of internal surfaces. The story of the evolution of backboneless animals discloses a long succession of achievements.

A step of great magnitude on the main line of evolution was the origin of backboned animals, with a new type of central nervous system opening up fresh possibilities of integration, registration, and experiment. There was a conquering of new media—the dry land and the air. There was a great extension of the range of behaviour and a widening of resources. Economised reproduction became possible as parental care lessened juvenile mortality. The individual became more of an individual and counted for more in life. Psychical linkages bound kin to kin.

Finally, Man emerged, "the summit of the whole".

Looking back over the great spectacle of Animate Evolution, we gather certain general impressions. There is progressive organisation of structural detail, increasing intricacy and correlation of functions, a complexifying of the inter-relations of organisms, a growing masterfulness and resourcefulness of behaviour.

The process of evolution from invisible Biococci to Mankind has a magnificence which cannot be exaggerated. It has been a process in which the time required has been of no consideration, in which there has been neither rest nor haste, in which by-paths show as much finish as the highways, in which broad foundations have been laid so that the superstructure has been secure, in which, in spite of the disappearance of masterpieces, there has been a conservation of big gains. It has had its outcome in personalities who have discerned its magnificent sweep, who are seeking to understand its factors, who are learning some of its lessons, who cannot cease trying to interpret it.

LECTURE XIII.

ORIGINATIVE FACTORS IN EVOLUTION: VARIATION.

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§ 1. *The Central Problem of Ætiology is the Origin of Heritable Variations.* § 2. *Variations Distinguished from Modifications.* § 3. *Discontinuous Variations (or Mutations) and Continuous Variations (or Fluctuations).* § 4. *Problem of the Origin of Variations.* § 5. *Correlation of Variations.* § 6. *Theory of Temporal Variations.* § 7. *Evidences of Definiteness in Variability.* § 8. *Germ-cells on Implicit Organisms.*

§ 1. *The Central Problem of Ætiology Is the Origin of Heritable Variations.*

While the general idea of evolution is accepted by practically all living naturalists, there is great uncertainty in regard to the factors that have been operative in the process. The uncertainty is partly due to the difficulty of arguing from a meagre experience of the present to a past of many millions of years, and partly to the fact that scientific ætiology is still very young, for it may almost be said to date from Darwin's *Origin of Species* (1859).

There are two main problems of evolution. The first asks how we are to account for the continual emergence of new things, of changes or variations which make an organism appreciably different from its parents or from the rest of its kin. The second asks what directive factors operate on the variations which arise, determining their elimination or their persistence as the case may be, and working, it may be, towards the familiar but puzzling result—the existence of distinct and relatively well-adapted species. The first question has to do with primary or originative factors; the second has to do with secondary or directive factors. It may well be, however, that the discontinuity of species depends more on originative than on directive factors.

A good many years ago there was born in a normal North of Scotland family a child who grew up to be a wise and well-proportioned dwarf. He married and had children—a certain number of whom were dwarfs. The peculiarity re-appeared in grandchildren and great-grandchildren, and one of the fourth generation was recently at the head of a successful business—a wise and well-proportioned dwarf. The question before us, discussible if not answerable, is, What conditioned the dwarf? This is the fundamental problem of the origin of the distinctively new. Whether it be a clever dwarf, a mathematical genius, a 10-foot tailed cock, a copper-beech, a Greater Celandine with laciniate leaves, the general problem is the same, the old problem of new departures. *What are the originative factors in organic evolution?*

§ 2. *Variations Distinguished from Modifications.*

A problem so difficult demands cautious handling. The first question is as to the nature of the novelties that actually occur; and the sound procedure is to take stock of all observed peculiarities or differences marking off individual organisms of the same kind. These "observed differences" must be measured and registered without theory or prejudice. We compare the colour of the trout we catch from different streams, the various numerical relations of radial canals and sense-organs in a thousand jellyfishes of the same species, the plumage in a score of ruffs, the number of vertebræ in a hundred herrings, and so on. We register these observed differences.

It soon becomes plain, however, that analysis of our data is necessary, if we are to avoid fallacy. We must try to sift out peculiarities which are associated with age and with sex, or are directly due to peculiarities of nurture. It is obvious that immature herrings must be compared with immature, and that we must not mix up the ruffs and the reeves, drones and worker-bees. More difficult, however, is it to separate off those peculiarities which can be experimentally shown to be individually acquired modifications, directly due to peculiarities in nurture (whether nutritional, environmental, or functional). Many crabs are profoundly changed by being parasitised by Sacculina and related forms, and a conclusion as to variability in crabs is vitiated by mixing up the parasitised with the normal. An organism dwarfed by lack of food or lack of space for exercise, such as the fresh-water snails studied by Semper and De Varigny, is in a different category from a normal dwarf appearing in a family with no dwarfs in its recent lineage. The much cut-up leaves of the fresh-water buttercup in the swiftly flowing water, one of the examples Lamarck gave of the direct results of environmental influence, are not to be placed alongside of the laciniate leaves of a variety of the Greater Celandine (*Chelidonium majus*) which cropped up without warning in 1590 in an apothecary's garden in Heidelberg, and has been breeding true ever since.

Darwin called these directly induced, exogenous modifications "definite variations"—not a fortunate term; they are currently and unhappily called "individually acquired characters"; they are best called "somatic modifications". They may be defined as individual bodily changes directly due to peculiarities in environment, nutrition, and function, which transcend the limits of organic elasticity and persist after the inducing causes have ceased to operate. As there is not at present any convincing proof of the transmissibility of these somatic modifications, either as such, or in any representative degree, they must be left out, in the first instance, in our inquiry into the origin of the distinctively new. They may be of great import for the individual, a life-saving veneer, but if they are not transmitted they cannot be of more than indirect importance to the race. It does not follow, however, that a changeful environment may not be an originative factor in evolution.

When we subtract from the total of observed differences those that can be shown to be modifications, when we also eliminate the peculiarities associated with differences of age and sex, the remainder are for the most part (in proportion to the success of our subtraction) what are called variations —inborn not acquired, intrinsic not extrinsic, blastogenic not somatogenic, endogenous not exogenous, arising from the constitution of the germ-cell not impressed from without, expressions not indents. Some of them at least are very transmissible, and it may be said that these constitute the raw materials of evolution.

§ 3. *Discontinuous Variations* (*or Mutations*) *and Continuous Variations* (*or Fluctuations*).

The next step is to inquire whether all the inborn variations are on the same platform, and here we may go back to Darwin's distinction between (*a*) "single variations" and (*b*) "individual variations", though the terms are not felicitous. (a) By "single variations" Darwin meant sports, abrupt changes, sometimes of notable amount, such as that which gave rise to the copper-beech in the 16th century, or to hornless cattle, or to short-legged sheep, or to Angora rabbits, or to fantail pigeons. They correspond to Galton's "transilient variations", to Bateson's "discontinuous variations", to De Vries's "mutations", and the last name should be kept for them. The contrast, it should be noted, is not so much in the amount as in the kind of change. A white rat does not seem to lack very much to make it a brown rat—the species whence it sprang, but it was in its day a qualitative new departure, and it has bred true. (*b*) By "individual variations" Darwin meant the minute, ubiquitous peculiarities which distinguish child from parent, brother from brother, cousin from cousin. Though he was much interested in the "single variations" or brusque "sports", it was in "individual variations" or minute fluctuations that he found most of the raw materials of new species. "The more I work," he said, "the more I feel convinced it is by the accumulation of such extremely slight variations that new species arise."

Some authors have tried to identify Darwin's slight individual variations or fluctuations with the somatic modifications already referred to. While this may be sometimes justified in point of fact, Darwin did not regard minute variations as modificational. This is plain from such a sentence as this: "If, as I must think, external conditions produce little direct effect, what the devil determines each particular variation?" Moreover, fluctuations or minute variations often arise among animals whose conditions of life appear to be quite uniform. On the other hand, what Johanssen calls fluctuations in "pure lines" of beans are probably slight modifications due to differences in nurture.

Little is known in regard to the transmissibility of fluctuations or minute variations in the Darwinian sense, but the recent work of Castle (1916), for instance, shows that it is in some cases demonstrable.

It is a curious fact that one of the reasons why Darwin attached little importance to sports or mutations was his belief that they would be swamped in the inter-crossing. In reality they are highly transmissible. When they come they often come to stay unless they are pathological on the one hand, or too superlative, like geniuses, on the other. What is desirable at present is more evidence of the transmissibility of the small fluctuations of germinal origin—a transmissibility which Darwin assumed without question.

To emphasise the contrast between fluctuating or continuous variations, and saltatory or discontinuous mutations, we may quote a couple of vivid sentences from one of Samuel Butler's *Essays.*

When circumstances are changing, an "organism must act in one or other of these two ways: It must either change slowly and continuously with the surroundings, paying cash for everything, meeting the smallest change with a corresponding modification so far as is found convenient; or it must put off change as long as possible, and then make larger and more sweeping changes".

"It may be questioned whether what is called a sport is not the organic expression of discontent which has been long felt, but which has not been attended to, nor been met step by step by as much small remedial modification as was found practicable: so that when a change does come it comes by way of revolution. Or, again (only that it comes to much the same thing), a sport may be compared to one of those happy thoughts which sometimes come to us unbidden after we have been thinking for a long time what to do, or how to arrange our ideas, and have yet been unable to arrive at any conclusion."

To the Dutch botanist De Vries especial credit is due for his recognition of the evolutionary importance of mutations and for his study of their behaviour in inheritance. It is an often told story how he found, in 1886, in a potato-garden near Hilversum, in Holland, a race of the Evening Primrose (*Œnothera lamarckiana*) in which the mood was all mutation. In spite of Galton's insistence on the reality of transilient variations and Bateson's marshalling of instances of discontinuity, the tendency had grown strong to dogmatise about the continuity of organic change, just as previously about the fixity of species. *"Natura non facit saltus,"* they said: but De Vries discerned *Natura saltatrix* in the Evening Primrose of Hilversum, which, by the way, turns out to have been in the 18th century a wild species in North America. Three points may be emphasised. First, that some of the mutants which De Vries's sportive Œnotheras threw off, as an artist might tear sketches from his note-book, were ephemeral failures, while others were viable and bred true, and could not be otherwise described than as species in the making, fingers searching as it were for their appropriate environmental glove. Second, in many cases the mutants were of particular interest because they showed through and through divergences—in leaf and stem and flower—certainly suggestive of some general disturbance of germinal organisation. Just as if the Œnothera was born again! Third, that the creativeness or sportiveness of the Evening Primrose is not restricted to De Vries's particular race of *Œnothera lamarckiana.* It occurs in other species of Evening Primrose, and also in snapdragon and barley, in strawberry and maize, in pomace-fly and potato-beetle, in rat and in Man himself. Mutations may be induced experimentally, as Professor Tower did with his potato-beetles and as Mme. Henri recently did with the bacillus of anthrax; or they may manifest themselves in wild nature as in the black mutants of Peppered Moth and West Indian Sugar-bird. The result may be a plus or a minus, a dominant or a recessive or neither, pathological or normal. The mutation may occur after crossing or in a pure race; it may show itself potentially before, during, or after fertilisation. In short, there is nothing hard and fast about the origin or nature of mutations: their common features are their brusque appearance, their discontinuity with the parent stock, and their capability of being transmitted intact to a certain proportion of the offspring.

The work of Dr. R. R. Gates on *Œnothera lamarckiana* is of capital importance. It had been suggested that this species might be a cultivated hybrid, and that its remarkable mutations might be re-combinations of the Mendelian characters of its parents. But it has been shown that *Œnothera lamarckiana* was in the 18th century at least a wild North American species. Moreover, the brusque phenomena of mutation occur not only in *Œ. lamarckiana,* but in *Œ. biennis, Œ. grandiflora,* and *Œ. muricata* as well.

Of particular interest in many of the mutations of *Œ. lamarckiana* is the fact that they affect several different parts of the plant, including foliage, flowers, and habits. The disturbance produced in the germ-plasm must be of a fundamental character, it has manifold outcrops, as is suggested by the names of the mutants—*gigas, lata, nanella, rubricalyx, brevistylis,* and so on.

How does Dr. Gates interpret the germinal disturbances which result in somatic mutations? "As regards the ultimate nature of mutations, we are inclined to look upon them as the result of various types of change in the nucleus: (1) morphological changes (*a*) in number, (*b*) in shape and size of the chromosomes, or in the arrangement of their substance; (2) chemical or functional changes in (*a*) whole chromosomes or (*b*) portions of particular chromosomes, by which a function may be modified or lost; (3) two simultaneous mutations may occur through mismating of the chromosomes in two pairs so that each germ-cell receives both members of one pair; (4) changes in the mysterious karyolymph or gel which forms the groundwork of the nucleus. Such changes may be thought of as alterations in chemical structure or even in polarity, and may also be supposed to extend to the ground substance of the whole cell. But the real nature of all such changes as those last mentioned is at present highly speculative" (1915, p. 303).

§ 4. *Problem of the Origin of Variations.*

Turning now to the problem of the origin of inborn variations, we may usefully distinguish two levels of difficulty. There are variations and variations. There are some novelties that imply just a little more or a little less of some quality,—a slightly longer tail, a slightly denser blackness, a slightly stronger flight-muscle, a slightly weaker eye; some that involve a disappearance of an entire character, such as hair or horns, tail or pigment; some that may be described as obvious re-arrangements of the characters displayed by the ancestry, as we see in a piebald pony or in a hybrid cockatoo. Now it does not seem very difficult to imagine the origin of this kind of quantitative variation. Without pinning our faith as yet to any very detailed view of the material basis of inheritance, we may regard it as certain that the chromosomes play an exceedingly important rôle as vehicles of the heritable qualities. We may compare them to a microscopic pack of cards and we know that they are sometimes visibly different from one another in the same germ-cell, and that there is an extraordinarily elaborate shuffling of the cards before development begins. In the reduction-process involved in the maturation of almost every animal egg-cell, half of the ovum's pack is thrown away, usually in the first polar body, and comes to nothing. In the maturation of the sperm-cell there is also a halving of the pack, but all the reduced units are in this case functional. In fertilisation the two half-packs come together in intimate and orderly union, though without fusion of chromosomes, forming the zygote-nucleus. The opportunities for permutations and combinations of hereditary items, and for the dropping out of one or more altogether, are many and actual. Thus the origin of variations of a quantitative sort does not seem beyond our comprehension, except in the sense that we do not in any way understand the process of cell-division, whether meiotic or reducing division in the maturation of the germ-cells, or the ordinary equational division in other cases.

That this is still only nibbling at the problem is evident when we think of meristic variations (in the number of parts, segments, vertebræ, joints, etc.), which Professor Bateson has usefully distinguished from substantive variations (in the composition of materials). A re-shuffling of the molecular cards within the germ-cell might give rise to a new pigment which was continued in subsequent generations as a definite constituent particle (which we have to credit with great capacity for increase) or as a particular chemical 'tendency' of the protoplasm; but how are we to picture the origin and continuance of meristic variations?

A separate consideration may be given to fertilisation as a source of variation,—a view prominent at one stage in the development of Professor Weismann's theories. For a time he was inclined to attach great importance to the mingling (or amphimixis) of two sets of hereditary qualities as a possible source of novelties, but he afterwards attached more importance to the influence that fluctuations in nutrition within the body might have in inducing changes in the germ-plasm or in inducing struggle among the analogous hereditary items. In recent years the Belgian botanist Lotsy has been a thoroughgoing champion of the variational significance of fertilisation and has gone the length of maintaining that all variation is due to crossing. There is ample experimental evidence that novelties may be induced by crossing, and this is not surprising when we remember that two very complex systems, usually of diverse origin, become in fertilisation a unity that goes on in most cases to develop into a harmonious life. On the other hand, Lotsy's attempt to refer all variations to crossing is extreme. This is shown, for instance, by the occasional occurrence of variations in parthenogenetic lineages in which no father intervenes for prolonged periods. Moreover, crossing can be of no avail unless the two sex-cells that combine are different. If they are different it must be by hypothesis because of previous crosses. Thus we simply push the problem back and back to original differences which are left unaccounted for.

The problem before which we are baffled is the origin of the distinctively new, where the novelty is qualitative not quantitative. Some would refuse to admit this distinction, and perhaps they are pedantically right: the distinction is one of common sense. There is many a grade between those who find their fingers indispensable in simple computations, and the calculating boy who can tell us in a few seconds the cube root of 2,498,846,293 yet cannot explain how he knows, but there seems good sense in recognising the latter as a qualitative change. So with the mathematical genius, the musical genius, the artistic genius, and there is not any reason to believe that Man is the only species that produces geniuses. The evidence of their occurrence elsewhere is in the rapidly-growing records of mutations of large amount. There is a mutation-theory, but is there any theory of mutations?

On the dark problem of the origin of the distinctively new some beams of light have been shed. (1) First, there are facts suggesting that deeply saturating environmental influences may act as variational stimuli on the germ-cells and provoke change. Professor MacDougal injected solutions of sugar and compounds of calcium, potassium, and zinc into the developing ovaries of one of the Evening Primroses, and got out of several hundreds of seeds sixteen individuals notably atypical, which bred true to the second and third generation. There were not only losses and augmentations, there were well-marked novelties which maintained their distinctiveness when crossed with the parental strains. It should be noted that what Professor MacDougal injected was not very much out of the way, and might be paralleled by natural changes in the chemical composition of the sap of the plant. Professor Punnett expresses the view of many naturalists when he says: "There is reason to suppose that environmental change leads to abnormal divisions in the ripening germ-cells, and that these abnormal divisions are the starting-point of the new variety" (Article *Heredity,* Hastings' *Encyclopædia of Religion and Ethics*).

Pointing in the same direction are the well-known experiments of Professor Tower, who subjected potato-beetles to unusual conditions of temperature and humidity when the male and female reproductive organs were at a certain stage of development. The results were strangely lacking in uniformity, but some of the offspring showed striking and persistent changes, not only in colour and markings, but also in some details of structure. Professor Tower's work has met with some adverse criticism, but, taken along with similar experiments, it suggests that we must not overlook the possibility of deeply-saturating environmental influences acting as variational stimuli,—affecting not the body of the parent, but the germ-cells within. Here should be included Weismann's view that fluctuations in bodily nutrition may prompt the germ-plasm to vary.

(2) Some of the researches of recent years, such as those of Dr. R. Ruggles Gates on Evening Primroses (Œnothera) and of Prof. T. H. Morgan on the Pomace-fly (Drosophila) have focussed attention on the chromosomes. It is a distinct step to know that certain peculiarities of particular mutants are associated with visible alterations in the chromosomes of the fertilised egg-cell. It is very interesting to know that while the fundamental number of chromosomes for the genus Œnothera is 14, this has become 15 in *lata* and *semilata,* 21 in *semigigas,* 28 in *gigas,* and so on. These are the numbers observed in the fertilised egg-cell and in every element throughout the plant.

In this connection a reference may be made to what obtains in Man. Competent observers have stated that the cells of the male negro have 22 chromosomes, and it is probable that the negress has 24, at least in some cases. Now in the white man and woman the enumerations of Winiwarter and others have usually been 47 and 48. It seems curiously difficult to reach certainty in regard to this simple point, but there is no harm in asking, as Dr. Gates does, whether the white man may not have originated from a black race by a "tetraploid mutation and its consequences".

The nuclear changes studied in Œnothera in their association with particular mutations are not restricted to changes in the *number* of chromosomes; they may concern their shape, size, and structure. What has been gained is a demonstration that in some cases the bodily peculiarities of mutants are correlated with visible changes in germinal organisation.

Now one is quite aware that this is just telescoping-down the Proteus of the full-grown organism into the germ-cell phase of its being, and that a recognition of germinal disturbances does not tell us what conditions them. As Professor Bateson has often said, we find ourselves confronted with the oppressive difficulty of cell-division and irregularities in its procedure. Yet there is an enlightening gleam in the proof that somatic mutations are correlated with antecedent germinal disturbances, for we know that abnormal cell-divisions occur in various conditions in Nature, and we have already referred to the opportunities for re-arrangements that occur in the early history and maturation of the germ-cells. Is there any further light?

We must remember that chromosomes are living units in a complex environment, and just as Bacteria sometimes change suddenly in their physiological properties, so chromosomes may vary in their stereochemic architecture or in functional powers. Moreover, it is not fanciful to suppose that these vital units, which have great persistence of 'individuality', may exhibit age-changes or periodic reorganisation processes.

Here may be profitably considered the recent work on the Slipper-Animalcule (*Paramecium aurelia*) by Professor Woodruff and Miss Erdmann. Woodruff has kept a pure line of this Ciliate healthy for over seven years, through more than 4500 generations. As is usual in a pure line all descended from one there was no conjugation. On an average of once a month, however, a remarkable regulatory process occurs, which the authors call endomixis, which secures the indefinite life of the race. Nuclear changes, comparable to those that precede conjugation in normal wild conditions, set in; the old nuclear material, both macronuclear and micronuclear, is disintegrated and re-organised. But there is no formation of stationary and migratory micronuclei as there is before conjugation. For conjugation is not going to occur; something that takes its place is occurring—*endomixis.* Now it seems probable that such a periodic re-organisation of nuclear material will afford opportunity for plasmic re-arrangement, and this may imply the origin of variations even within a pure line. Professor Jennings has found in pure lines of non-conjugating Paramecium evidence of variations about the mean. These might be due to re-arrangements effected in endomixis. It is conceivable, as Woodward and Erdmann point out, that "heritable" variations may result from some rare recombinations in endomixis.

This Paramecium is a very complicated organism, as Prof. Clifford Dobell has vividly emphasised, on the noncellular line of evolution, and we find it in certain conditions exhibiting a monthly re-organisation as part of its life-cycle.

Is it not possible that some similar re-organisation may normally occur in Metazoa at the origin of each individual life, and that, if it does, there is no need to look about for any special cause? It is all in the day's work, it is part of the programme of the essentially regulative life-cycle. We may recall, too, that variation occasionally occurs in parthenogenetic or aspermic development, as well as in the ordinary process.

We are not seeking to 'explain' variations by verbal inventions. Our argument is quite clear: Certain mutations in organisms are preceded by germinal disturbances, perhaps these germinal disturbances are comparable to endomixis in Paramecium. It is always a step towards understanding to put one obscure process alongside of another which is similar to it and which may be more amenable to experimental treatment. Therefore we suggest that endomixis may be profitably considered along with the problem of the origin of variations.

Another gleam of light may possibly be found in Professor Child's long-continued study of processes of senescence and rejuvenescence,—a study recently presented in its entirety in a remarkable volume *Senescence and Rejuvenescence* (1915). Professor Child finds that when a fragment of a Planarian regrows a whole, there is a rejuvenescence during the re-constitution; the rate of metabolism is high and the resistance-power is great. The metabolism may be measured by Tashiro's 'biometer', an extraordinarily delicate register of the CO_2 output, or more indirectly by the degree of susceptibility and resistance to cyanide poisons and the like. Judged by these tests, the regenerating piece of Planarian is younger than it was when it formed part of the parent. It literally renews its youth. Similarly, when a Planarian or a Hydroid multiplies asexually, the separated-off piece shows marked rejuvenescence as revealed by the two tests named.

Professor Child's thesis is this: As an organism differentiates, it ages, for the accumulation of relatively inactive constituents in the colloidal cytoplasmic substratum necessarily involves a decrease in the metabolic rate; but there are counteractive processes of reduction, removal, and de-differentiation, when the metabolic stream erodes its bed instead of depositing materials. These are marked by acceleration in metabolic rate, and constitute rejuvenescence. "It is certain," Professor Child says, "that the new individuals which arise by division or budding from other individuals or from experimentally isolated pieces are to some extent physiologically younger than the parent individual from which they arose."

The idea of a see-saw between processes of senescence and rejuvenescence finds many illustrations among the lower animals, but what of higher levels? Professor Child finds some interesting evidence that the early developmental stages of a number of animal types, before specialisation of cells sets in, are conspicuously young in the physiological sense. The germ-cells themselves are very stable condensations of hereditary items, but in the early development there is a time of re-constitution, of de-differentiation, of relaxation. If there is any soundness in this view, in support of which data are, of course, submitted, we may perhaps recognise another opportunity for variation, namely in the very young embryo, where the alleged rejuvenescence may include possibilities of re-arrangement and, as it were, re-tuning.

§ 5. *Correlation of Variations.*

The tendency of modern research has been to lay emphasis on the idea of hereditary particulateness, that the characteristics of organisms are made up of elementary units, without intergrades, as sharply separated from one another as the chemical elements. This is the idea of "unit characters", independently heritable, and independently variable. It is very striking that a trivial feature in the hands—a reduction of the index and middle finger (in spite of the presence of a little extra triangular bone at their bases), and a consequent projection of the ring finger, should behave as a Mendelian character for at least four generations and be found in fifteen out of thirty-six descendants of the family investigated. (See H. Drinkwater, *Journ. Anat. Physiol.*, L., 1916, pp. 177-186, 14 figs.) There is indirect evidence that particular unit characters are represented by particular particles (factors, determinants, or genes) in the germ-plasm, or perhaps by ultra-microscopic differences of architecture, and the idea works well,—like the atomic theory in chemistry. But it has its limitations and it must not be pressed so hard that we lose sight of the unity of the organism even in the germ-cell phase of its being, and of the fruitful conception of correlated variations. An exaggeration of the idea of particulateness leads to a view which is too mechanical to fit living creatures, as if the organism evolved like a machine perfected piecemeal by the adding on of many little patents independent of each other. A reaction may be seen in the recent book by Prof. T. H. Morgan and others on *The Mechanism of Mendelian Inheritance* (1915), where it is insisted that the so-called unit character is only the most obvious or most significant product of the postulated 'factor', that the effects of a 'factor' may be far-reaching and manifold, and that a single character may depend on many 'factors' which interact. "Cases of interaction of factors, in which the effect of one factor is altered by the action of another factor, are very numerous" (p. 46). "The expression of a factor-difference may not be limited to one region but may produce a different effect in different regions."

Many considerations suggest that we should do well to appreciate afresh the idea which Darwin and Sir Ray Lankester have emphasised of the "correlation of variations", that one change, as we see for instance in disease, may have manifold expression or outcrop in different parts of the body, that the organism may change as a unity in many parts at once. It is not difficult to suppose that a change in the rate of a particular kind of metabolism may reverberate through the body. As Mr. J. T. Cunningham and Professor Dendy have pointed out, an augmentation or a diminution of certain internal secretions or hormones might have multitudinous transforming effects.

§ 6. *Theory of Temporal Variations.*

Another important idea is that of temporal variations, that is to say alterations in the tempo, or rate, or rhythm of metabolic processes, or in the duration of particular phases in the life-cycle. Many changes of great adaptiveness are probably due to a lengthening out of one chapter and the telescoping of another. In the remarkable regulatory influence of the internal secretions in backboned animals we get a hint as to the way in which changes in 'time' might be effected.

It is very interesting to compare different life-histories from this point of view. In some, such as May-flies or Ephemerides, the adult life is condensed into a few days or even hours. It may even be lost altogether as in cases of pædogenesis, where there is juvenile reproductivity. On the other hand, when juvenile life is hazardous, it may be, as it were, telescoped down into the egg; thus the young Mound-bird is able to fly on the day on which it is hatched. In other cases, as in the generations of Planarians badly fed, the animal may be born old. Part of the tune may be played very slowly, part very quickly, and another part left out altogether, and a life-history adaptive to particular conditions may be the result of selecting out suitable temporal variations. (See in this connection Mitchell, 1912, and Thomson, 1914.)

We must not think too exclusively of variations in structure; many variations may affect rate and intensity; many may be differences in stability of constitution, in rapidity of reflexes and cerebral processes, and in the mysterious quality called vigour. Or, penetrating further still, may we not recognise the possibility of a kind of variation which is of more profit than any increase of stature, strength, or speed, than any perfection of armour or weapons, than any subtlety of protective coloration or mimetic resemblance,—a kind of variation that expresses itself in a keener endeavour after well-being, a stronger will to live, and a livelier sense of kinship?

§ 7. *Evidences of Definiteness in Variability.*

For our interpretation of evolution it is important to recognise the growing body of evidence that variation is a much more definite, much less fortuitous, organic change than was formerly supposed. (A) There are many illustrations of what is called orthogenesis, or progressive variation along a definite line. The palæontologists in particular have very strong convictions as to reality of this orthogenesis, and as to the absence of arrows shot at a venture. (B) Instances are accumulating of the occurrence of mutations or brusque variations, and if these come they often come to stay. The Black Mutant of the Peppered Moth was rare 60 years ago; in many places it has now replaced the originative stock. This lessens the element of the casual in organic evolution. It also lessens the need for over-burdening the rôle of natural selection in sifting out from amid a crowd of random novelties, and as an accumulator of minute increments. (C) But along with this there should be considered the idea, that variations are limited in some measure by what has gone before. At the beginning of each individual life there is the fertilised ovum,—a viable unity. If a variation occur it is not like to grip unless it be congruent with the germinal organisation already established; it must harmonise, just as an addition to a crystal must, but within a wider range. The character of the building that has been erected determines in some measure the nature of an addition to it. The idea of architecture is of course only one aspect; the novelty must be congruent with the previously established reaction system and specific metabolism. Out of the same spring we do not get sweet water and bitter. This is an old but important idea; we find in Aristotle the suggestion that the possible range of the form of an organ is limited to some extent by its existing differentiation. Thus the element of the fortuitous shrinks still further. It is interesting to find that monsters sometimes result from infelicitous crossings, but perhaps a greater interest attaches to the fact that monsters are rare in Nature, not only in survival, but in occurrence.

An illustration of the limiting of changes by pre-existing organisation may be found in a recent paper by Prof. S. J. Hickson (*Mem. & Proc. Manchester Lit. & Phil. Soc.*, LX., 1916, pp. 1-15), in which he notes that meristic variability in important organs is much greater in radially symmetrical forms than in bilaterally symmetrical forms where a balance must be kept. In reference to the Pennatulacea he shows that variable or plastic characters may become less variable or plastic as a transition is made from radial to bilateral symmetry, and points out that increasing rigidity of certain characters leads in some cases to the differentiation of the discontinuous groups which are recognised as species. What we would suggest is carrying this idea from the fully-formed organism to the germ-cell organism, and considering substantive as well as meristic variations.

§ 8. *Germ-cells as Implicit Organisms.*

Let us sum up. Germinal disturbances or re-arrangements occur and these may find expression in development as variations or mutations of the organism. The question is, What brings about the re-arrangements?—a question to be asked in the light of the fact that, frequent as variations are, hereditary constancy, or inertia, or persistence of specificity is even more marked. The following suggestions are before us. (1) That germinal disturbances come about in response to subtle environmental stimuli of a novel kind penetrating in from without and affecting cell-division, or the architecture of the chromosomes, or perhaps the "mysterious karyolymph or gel which forms the groundwork of the nucleus". Along with definable changes in the external environment may be included changes in the somatic fluids which might affect the nutritive or other metabolism of the germ-cells. (2) That in the division of the germ-cells before fertilisation, where there has to be a partition of a complex cytoplasmic and chromosomic cargo between two vessels, losses and augmentations and inequalities may be expected in the transhipment. (3) That in fertilisation, with its intimate and orderly union of paternal and maternal contributions (amphimixis), there may be opportunity for new permutations and combinations, the result normally being a viable unity of dual origin. (4) That there may be growth-changes, or regulative reorganisation processes, or rejuvenescences in the germ-cells in the course of their history; and it is possible that there may be something in Weismann's hypothesis of intra-germinal struggle.

We are thus aware of certain originative factors in evolution, which admit of experimental testing, and we should not lose sight of any of them. Each must be pushed as far as it will go. Recognising this, some will insist that there is no more to be said, but much to be done. We venture to doubt, however, whether this is not making a tyranny of scientific method (which, after all, is very selective and partial) and giving up the right of speculative adventure. As Karl Ernst von Baer, the great Russian embryologist, said: There is observation, but there is also reflection.

Those who have devoted much attention to the occurrence of variation, we think for instance of Darwin and Bateson, have given emphatic expression to their sense of the difficulty of accounting for the origin of the new. The fountain of change, whence are its well-springs? "As to almost all the essential features, whether of cause or mode, by which specific diversity has become what we perceive it to be, we have to confess an ignorance almost total" (Bateson, 1913, p. 248). But we also notice that some of those who have given much of their life to the study of the phenomena of variation occasionally lapse from the stern path of science, and in face of the difficulty of the problem ask themselves if they are allowing enough for the fact that the organism is alive. Thus we would quote from the recent work of Dr. R. R. Gates on *The Mutation Factor in Evolution* this interesting sentence: "Just as an Alpine climber dangling over a chasm may, by changing his hold, swing himself on to a shelf from which he can make a fresh start in some other direction, so we may think of the organism trying many unconscious experiments in its offspring, some of which are hurled by the gravitational effect of natural selection into the abyss of extinction while others with a more fortunate turn rest on a ledge of safety whence new essays of variability begin." But Dr. Gates mutationist all too speedily takes the place of Dr. Gates psycho-biologist. After this one exciting glimpse of the organism as climber we are hurried back to the chemical and physical complexity of the protoplasm and its unique irritability and retentiveness. But we are disposed to linger over the idea of the organism as climber, and the organism here means the germ-cell. It is not suggested that the germ-cell is dominated by any purpose of getting to the top of anything, or of circumventing any particular difficulty, but rather that there is inseparable from it a restless experimenting in self-expression, bearing the same relation to the insurgent self-assertiveness of the full-grown creature that the tentatives of dreamland bear to the achievements of open-eyed and deliberate endeavour.

The position we are suggesting is that the larger mutations, the big novelties, are expressions of the whole organism in its germ-cell phase of being, comparable to experiments in practical life, solutions of problems in intellectual life, or creations in artistic life. These are accomplished, every one knows, by molecular activities in the brain and body, but they are not intelligibly thought of unless we conceive of the organism as a psycho-physical individuality, a mind-body, or body-mind, as we will. Similarly it may be that our conception of germinal variability is falsely abstract unless we recognise that germ-cells are living individualities of great complexity telescoped-down into a one-celled phase of beings, and that they too make essays in self-expression.

Mr. E. S. Russell (1915, p. 430) has suggested that non-adaptive specific differences which make species discontinuous may be profitably compared to the differences between related organic compounds, and that they may be due to differences in metabolism or stereochemic architecture which cannot be other than discontinuous. But adaptive specific characters, whether of internal or external reference, may be the result in the long run of some "obscurely psychic capacity for active effort". "The analogies between intelligent and instinctive behaviour on the one hand and the organic processes of active adaptation on the other, as these are expressed in changes of form, are striking and profound." Mr. Russell goes on to say that behaviour and morphogenesis are probably different manifestations of one and the same fundamental capacity which cannot be formulated adequately without using psychical terms.

If it be said that this is retrograde science to fall back on psychical formulation because of the baffling difficulty of physiological formulation, and that it is a reversion to the mediæval solution of the problem of digestion and the like by calling in the aid of Archegæus and other indwelling spirits. But it may be answered first, that in giving an account of our own behaviour it is not a hypothesis to regard psychical factors as *veræ causæ,* that somehow or other the psychical factors we are aware of were implicit in the germ-cell whence we sprang, and that therefore it is not a reversion to mediæval physiology to keep our mind open to the possibility that the origin of the profounder and more vital variations may not be statable without a recognition of the implicit organism of the germ-cell as at once psychical and metabolic.

Perhaps we mislead ourselves by repeating too often the elementary commonplace that the Metazoon begins its life as a single cell. It is true enough in a way, but certainly not the whole truth. It is no commonplace cell, the gamete. It is an implicit organism and within it, in some manner that we cannot begin to image, though we crowd it with factors and genes (the modern successors of Darwin's gemmules and Weismann's determinants), there lies a complex inheritance, unified afresh at the start of each new generation. If an Amœba has a behaviour, as Professor Jennings seems to have proved, may not the much more richly-endowed germ-cell of a fruit-fly be allowed the capacity of putting its house in order? If the Foraminifer *Technitella thompsoni* picks and chooses the materials of its encasement and builds this with what looks like a dawning art, may not the ovum of an Evening Primrose be allowed some freedom of internal architecture? Germ-cells are not corpuscles of undifferentiated protoplasm. They are individualities that live and multiply, that struggle and combine. They are repositories of multiplicate inheritances borne by strangely persistent smaller living units, the chromosomes, which adjust themselves in the most momentous of organic compromises. Is it fanciful to suppose that these gametes, neither simple cells nor portmanteaus of hereditary factors, but unified individualities, experiment internally, not fortuitously but artistically, not at random nor yet inexorably, not purposefully but perhaps purposively, and that they are body-minds or mind-bodies telescoped down?

In certain moods one feels inclined to agree with those who say to-day what Darwin said more than fifty years ago that our ignorance of variation is profound, and who urge the appropriateness of silence. Yet perhaps it is more wholesome for thinkers to have an exposure of the vast uncertainty that surrounds this central problem of biology than to be led astray by those who confidently declare that organic evolution can be mechanically re-described. If the re-description is difficult and still impossible when we use full-blooded biological categories, how must it be if matter-and-motion categories are supposed to be the only legitimate ones?

SUMMARY.

The central and most difficult problem of ætiology concerns the origin of the new, that is, of those variations or mutations that form the raw materials of progress or the reverse.

From an unbiassed registration of all observed differences between the members of the same species there have to be subtracted all the peculiarities that can be reasonably interpreted as associated with age and sex, or as individually-acquired somatic modifications directly due to peculiarities of nurture, whether environmental, nutritional, or functional. As there is no convincing evidence at present that these extrinsic somatic modifications can be transmitted as such, or in any representative degree, they cannot be included, in the first instance at least, among the raw materials of racial evolution. These are discerned when the modifications in question and the peculiarities associated with agé and sex are subtracted from the total of observed differences. For this subtraction brings into view the true variations or mutations—inborn not acquired, blastogenic not somatogenic, endogenous not exogenous, expressions or outcomes not indents or imprints. Some at least are very transmissible, and these furnish the raw materials of evolution.

Among inborn variations it is useful to distinguish between mutations (Galton's "transilient variations", Bateson's "discontinuous variations") and small fluctuating variations. The former arise brusquely, with a measure of perfectness from the first, without intergrades, and are markedly transmissible. The latter are of the nature of "a little more or a little less", they show intergrades; their transmissibility has not been much studied, but it has been proved in a few cases.

It is also useful to distinguish quantitative variations from definite novelties. The reduction or exaggeration of a quality, the dropping-out of a character altogether, a re-arranged pattern of hereditary items, may be called quantitative, and may be explained as due to permutations and combinations of the determinants or factors of hereditary characters. For such shufflings of the cards ample opportunities are afforded in the course of the maturation of the germ-cells.

Another possibility is afforded at the beginning of each individual life, where, in the great majority of cases, two very complex systems of dual origin become a new unity which normally develops into a harmonious organism. Some modern evolutionists attach great importance to crossing as a cause of variations.

But the greater difficulty is with the origin of the distinctively new, of what may be called qualitative variations or mutations. (a) It may be that deeply-saturating environmental influences act as variational stimuli on the germ-cells, provoking change. (b) Definite changes in the nuclear bodies or chromosomes of the germ-cell have been proved to be associated with particular mutations in the full-grown organism, and, in addition to the opportunities for chromosomic change afforded in the history of the germ-cells—before, during, and after fertilisation—it is possible that chromosomes, which are living units, may change suddenly like Bacteria, or may undergo age-changes, or may exhibit periodic re-organisation like slipper-animalcules, or rejuvenescence-changes like those occurring in some cases of regeneration and asexual multiplication.

The tendency of modern research is to emphasise the idea of particulateness, for it looks as if the characteristics of organisms were often made up of elementary units, without intergrades, as sharply separated from one another as the chemical elements. But we must not lose sight of the unity of the organism, even in the one-cell phase of its being, and of the correlation of variations. A change in some particular kind of metabolism may reverberate through the whole body.

Another important idea is that of temporal variations, that is to say, alterations in the 'time' or rate or rhythm of metabolic processes, or in the duration of particular phases in the life-cycle. Many changes of great adaptiveness are probably due to the lengthening out of one chapter and the telescoping of another. In the influence of internal secretions in backboned animals there is a known method of effecting these changes in 'time'.

Of great importance for our interpretation of evolution is the growing body of evidence that variation is often a much more definite organic change than was formerly supposed. There are many illustrations of progressive variation along a definite line,—orthogenesis. Instances of mutations are accumulating, and if mutations come they usually come to stay. This also lessens the element of the casual and the need for over-burdening Natural Selection with the task of sifting from amid a crowd, and of accumulating minute increments. Furthermore, variations occurring in a unified individuality are not likely to be stable unless they are congruent with the organisation already established. Thus there seems little warrant for talking about evolution as a "chapter of accidents".

It may well be that our conception of variability is fallaciously abstract unless we recognise that germ-cells are living organisms of great complexity telescoped down into a one-cell phase of being, and that they make essays in self-expression which we call variations. These blind experiments of the germ-cells are submitted to the developing and adult organism to be tested in actuality.

LECTURE XIV.

DIRECTIVE FACTORS IN EVOLUTION: SELECTION.

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§ 1. *Selection the Central Idea in Darwinism.*

The central idea in Darwinism is the natural selection of the relatively fitter variants in the struggle for existence. Our understanding of Darwinism must therefore depend on our appreciation of what is implied in variation, in the struggle for existence, and in selection. A rough and ready understanding of it is easy, but when we are dealing with living creatures that is apt to mean misunderstanding, and so it has been. By the hasty-minded, and by those more anxious to score points than to get at the truth, Darwinism has been persistently misunderstood. This has been largely due to trusting to second-hand impressions instead of going to Darwin's own works. Natural Selection may be described as the process by which, in the struggle for existence, certain variants of a species, marked from their fellows by the presence or absence of some innate character, are on that very account favoured with longer life or with more successful families than their neighbours, who are on that account sooner or later eliminated. Darwin stated his theory in a couple of sentences: "As many more individuals of each species are born than can possibly survive, and as, consequently, there is frequently recurring struggle for existence, it follows that any being, if it vary however slightly in any manner profitable to itself, under the complex and sometimes varying conditions of life, will have a better chance of surviving, and thus be naturally selected. From the strong principle of inheritance any selected variety will tend to propagate its new and modified form."

§ 2. *Logical Objections to Darwinism.*

From Darwinism there have been several hasty recoils, some logical and others sentimental, but both due to misunderstanding. Let us take first the logical, and second the emotional or sentimental recoils. At a later stage we shall consider the emendations of Darwinism which further investigation has necessitated—a very different matter.

(*a*) It is a misunderstanding of Darwinism to dwell on the fact that Natural Selection is not originative, only directive; that it is comparable to the action of pruning shears or of a sieve, not to the welling forth of a spring; that it corresponds to Siva, the destroyer, rather than to Brahma, the creator. That is quite true, but while Darwin sometimes spoke for brevity's sake of the creative work of Natural Selection, he made it quite clear that the sifting process could only operate on the raw materials which the variability of organisms brought within its scope. When we say that the strange shape of an evergreen in the garden is due to the gardener's shears, we do not forget the growing living plant. So when we say that the wing of a bird is the outcome of selection, we do not forget the varying organism, strong in endeavour. One forgives much to Samuel Butler in admiration of his genius, one forgives even the jibe that "Darwinism tries to explain how I am here by showing how my uncles, cousins, and aunts have gone away". But it seems to us to promote misunderstanding when an expert writes in cold blood—"Darwin . . . left the question of variability open, a course which reduced his doctrine to the self-evident proposition that what was not capable of existence could not exist". . . . "Darwinism . . . explained how by throwing stones one could build houses of typical style" (Driesch, *History and Theory of Vitalism.* Trans. London, 1914).

(*b*) It also promotes misunderstanding to make very much of the fact that Natural Elimination is often a more accurate phrase than Natural Selection. A wonder-working gardener like Mr. Luther Burbank actively selects and fosters variants that catch his eye and seem to him to be promiseful; what happens in Nature is in great part a weeding-out of the relatively less fit to given conditions. But it is familiar Darwinian doctrine to distinguish between 'lethal selection' which works by the discriminate elimination of the relatively less fit, and 'reproductive selection' which works through the increased and more effective multiplication of the relatively more fit. As a matter of fact the weeding out of the relatively less fit must always to some extent involve the fostering of the relatively more fit which survive.

§ 3. *Sentimental Recoil from Darwinism.*

(A) The sentimental recoil from Darwinism may be illustrated by those who shudder at the so-called automatism of the selective process. The raw material of novelties passes over an unending sieve which never ceases to sift; an uncertain fraction of the variants pass through the meshes and are ground to powder 'twixt the upper and the lower millstone; another uncertain fraction escapes and continues its kind. These are no mills of God, but of Moloch, and all is dread automatism. But it was to remove this misunderstanding that we lingered in a previous lecture over the struggle for existence, and saw that it included all the individual endeavours and answers-back which creatures with a will to live and abundance of resource make to their environing limitations and difficulties. After allowing a little for chance, the relatively best candidates will come to the top in a number of wisely and accurately conducted examinations. This is not mechanical or automatic; neither is Natural Selection. We must recognise that Natural Selection includes all the subtlety of endeavour, all the patient perseverance, all the indomitable insurgence, of living creatures. They share in their own evolution; they often help to make the sieves by which they are sifted.

(B) Another sentimental reason for recoil is because of the supposed grimness of the selection-method. "Contention is the vital force"; rank individualism is the order of Nature; "Each for himself" is the cry from every corner, and extinction take the hindmost. It is a vast gladiatorial show, said Huxley, this Nature,—a dismal cockpit. But, as we have seen, this is a travesty. The struggle for existence is a metaphor, it includes every new endeavour after well-being; it is rarely very intense between near kin; it is often not competitive at all. One organism survives, indeed, by sharpening its claws and whetting its teeth, but another by increasing maternal care or mutual aid.

Speaking of the Darwinian conception of the way in which evolution has chiefly been brought about, Prof. Arthur O. Lovejoy (1909, p. 93) writes: "The doctrine of natural selection represents Nature as a scene of monstrous waste and of universal conflict, a veritable *bellum omnium contra omnes.* It pictures the teeming Universal Mother as reckless in the production of aspirants for life, but strangely parsimonious in her provision of the means of maintaining life,—leaving to every one of the hungry children at her board only the privilege of snatching the food of his neighbours, only the grim alternative of destroying or being destroyed." . . . We quote this as typical of common caricatures, not as representing Professor Lovejoy's own picture of Natural Selection. There is a tendency to exaggerate the destructiveness and instability of wild nature. Apart from man's interference, which is quite *per se,* cases of rapid disappearance of species, as in the Passenger Pigeon, are rare, and are very puzzling. What is impressive is the Live-and-let-Live equilibrium, the stability of species. Mr. F. C. S. Schiller writes that "Every species is in constant danger of extinction", but one would like to have the evidence for such a statement. The fact is, that many species have attained to positions of extraordinary stability and security.

§ 4. *Changes in Selection Theory since Darwin's Day.*

It would be ominous if the theory of Natural Selection stood to-day as it did in Darwin's lifetime. Emendations have been made and saving-clauses have been added, and while extreme critics hold that the theory has been discredited, this conclusion is largely due, we think, to taking the theory in a wooden way and failing to realise its full significance. Before we consider typical criticisms, it will be convenient to discuss some of the positive changes in the theory.

(1) There has been in a few cases a welcome demonstration of Natural Selection at work. The theory is not merely a hypothesis as to what might have happened long ago; it is a statement of what does happen now. There is some actual proof of discriminate selection, where the survivors are shown to survive in virtue of the possession of particular qualities. Let us take a well-known diagrammatic instance, (Cesnola, *Biometrika,* 1904). The praying Mantis, *Mantis religiosa,* occurs in Italy in a green and a brown variety, the former usually on the grass, the latter usually on the withered herbage. The Italian naturalist Cesnola tethered twenty green Mantises among green herbage and a similar number of brown ones among withered grass. After seventeen days they were all alive, having escaped the notice of their enemies. He tethered twenty-five of the green variety among brown herbage; all were dead after eleven days. In the converse experiment, of forty-five brown insects exposed on green grass, only ten survived at the end of seventeen days. Most of the Mantises were killed by birds; five of the green ones were killed by ants. The experiment should be extended, but it proved the selective value of the coloration. If green and brown Mantises were exposed in a green country, the green ones would survive, the brown ones would be eliminated, and the selective death-rate would have reference to the particular quality of coloration. Similar experiments have been recorded by Professors Poulton, Crampton, Bumpus, and Weldon—all proving discriminate elimination. Prof. Karl Pearson has also demonstrated the occurrence of a selective death-rate in man.

These demonstrations require more exposition than is here possible, but, as we are dealing with one of the most important of biological theories, with the question of the directive factors in evolution, we may cite from a previous discussion two simple observations which illustrate discriminate elimination picturesquely (Thomson, *Darwinism and Human Life,* 1911). Prof. C. B. Davenport, of the Carnegie Institution for Experimental Evolution, had 300 chickens in a field, eighty per cent. white or black and conspicuous, twenty per cent. spotted and inconspicuous. In a short time twenty-four were killed by crows, and it was interesting to observe that only one of the killed was spotted. The elimination seemed to be discriminate, and in wild conditions it would doubtless have led to the elimination of the conspicuous variants. It will be understood that we are not attaching great importance to any individual case, such as this, for criticism and corroboration are required all round; we are giving an illustration merely.

In a heavy snowstorm at Johannesburg in August, 1909, many hundreds of trees were destroyed by the weight of snow on the branches. In many places the roads were blocked by the fallen trees. It was interesting, after the storm, to notice that the elimination was in a marked degree discriminate. The trees that suffered most were the imported Australian trees, such as the Blue Gums and Black Wattles, quickly growing, with soft wood, and with abundant foliage that caught the snow. On the other hand, the Deodars from the Himalaya mountains, constitutionally adapted to let the snow slide from their pendulous branches and acicular leaves, had hardly a twig broken.

(2) In the second place, the position of the selection theory has been strengthened by a recognition of its manifoldness. It takes several different forms, the logic of which

is the same. When Darwin says "Natural selection acts by life and death . . . by the survival of the fittest and by the destruction of the less well-fitted individuals", he describes *lethal* selection. Insects with reduced wings or none at all abound in wind-swept islands like Madeira, the flying insects having been blown out to sea and destroyed. When Weismann points out that the animals best adapted to the colour of their surroundings will secure the most abundant food and multiply most prolifically, and will thus increase the numerical proportion of others like themselves, he is describing *reproductive* selection. If an advantageous character is linked to an increase of fertility it will tend to persist apart from lethal lopping off. In the cultivation of a lawn one may eliminate the weeds by direct lethal selection; but one may also stimulate the multiplication of the grass by giving it a specific food which is not profitable for the weeds. There is a special form of selection in the sometimes fatal combats of rival males, and in preferential mating when there is evidence of discrimination on the female's part. There is social selection between rival ant-hills, where community sometimes competes with community, and, at the other pole, there may be selection between potential egg-cells, the ovarian struggle sometimes ending in the survival of one out of many, and selection between the hundreds of sperm-cells in their race towards the ovum. Allowing a wide margin for chance, the most vigorous and perhaps the most sensitive spermatozoon will tend to succeed, and the elimination of the others by the blocking of the entrance to the egg will be for the advantage of the species. As Weismann suggested, it is also possible that fluctuations in the nutritive supply of the germ-cells, and inequalities in the vigour and assimilating power of the hereditary constituents or determinants, may result in an intra-germinal struggle and selection. But we need not go further, since our point is simply that the selective processes are probably more manifold than even Darwin realised.

(3) Whenever we turn from expositors of Darwin to Darwin himself we discover afresh how subtle was his idea of the process of Natural Selection. We realise, for instance, that the selection need not imply a sudden elimination of the relatively less fit, for a persistently shortened life and a consistently unsuccessful family will work to the same result in the long run as lopping off heads. As Professor Punnett puts it: "If a population contains .001 per cent. of a new variety, and if that variety has even a 5 per cent. Selection advantage over the original form, the latter will almost completely disappear in less than a hundred generations." In human affairs we may be thus encouraged in patience. It has also to be realised that the web of life has so fine a texture that apparently trivial differences in organisms may be of critical moment in determining the survival of those who possess them. And just as in animal courtship what determines the female's preference for one suitor out of many is very probably an irresistible *tout ensemble* of gifts and graces, rather than excellence in one particular decoration or quality, so in natural selection it may be that what gives survival value is often a general stability of constitution and efficiency of behaviour. In a well-known instance when 136 storm-spent sparrows were brought into shelter, 72 revived and 64 died. Careful measurements showed Professor Bumpus that the eliminated birds were less near the normal than those which survived. Except in one measured character, the range of variation was greater in those that succumbed. Thus while natural selec-

tion may operate with great delicacy in reference to a sieve with fine meshes, it may also rough-hew and cut off in a crisis a large number of organisms which are in a general way less fit than their fellows. As Professor Bumpus said, general stability of structure was the essential characteristic of the surviving sparrows (Bumpus, 1898).

(4) An interesting corollary to the selection proposition is that a relaxation of sifting may admit of exuberance. When organisms reach a position of relative security, as many species do, then, the criticism of circumstances being removed, there may be extraordinary abandon in the way of coloration and decoration. The limit is the stability of the constitution; the risk is that some environmental change may involve a heavy tax on the exuberance which the conditions of relaxed selection tolerated. It may be one reason of the diversified brilliance of humming birds that they have few enemies. A clearer case is to be found in the coral-fishes, whose exuberance of coloration beggars description (see Reighard). It may be that the gorgeousness has been made possible by the safety of the labyrinthine reefs, and by the agility of the swimmers. Prof. J. P. Lotsy (1916) speaks of the bewildering diversity exhibited by a series of about 200 specimens of the Common Buzzard (*Buteo buteo*) in the Leiden Museum, "hardly two of which are alike". "The reason probably is that here *no selection* has been at work, because this bird of prey is so strong that it has practically no enemies in the regions in which it occurs."

(5) Of great importance is the change that has been involved in our appreciation of Natural Selection by an increased knowledge of the raw materials supplied to the sieve by variability. As we have seen, discontinuous variations or mutations are not of rare occurrence; there is a brusque

passage from one position of equilibrium to another; the Proteus leaps as well as creeps. An advance marked from the first by a certain measure of perfectness is made at a stride, not by minute steps generation after generation. A copper-beech, a laciniate celandine, a hornless calf, a calculating boy, or the like, just appears—out of the inexhaustible conjurer's box. Now it is plain that as the list of these mutations or saltations grows in length, the lighter will be the burden that has to be laid on the shoulders of Natural Selection. Apart from the palæontological record it is only by analogy from the present that we can argue back to what occurred in the distant past, but it looks as if mutations were much more frequent than has been till recently supposed, and the more frequent mutations were in the past, the less work would there be for Natural Selection to do in the way of fostering small increments in a particular direction.

It is quite premature, however, to think of abandoning the idea—so characteristically Darwinian—of the cumulative importance of minute advances. Many palæontologists insist on the origin of new characters "by excessively fine gradations which appear to be continuous" (Osborn), and also on the frequent occurrence of orthogenesis, *i.e.*, change in a definite direction without marked divagations. As Prof. H. F. Osborn says (1919), the palæontological record often confirms the prophetic judgment of Aristotle: "Nature produces those things which, being continuously moved by a certain principle contained in themselves, arrive at a certain end."

We must be on our guard, however, against the possible fallacy of concluding, from the apparent orthogenesis in fossilised and surviving stages along an evolutionary line, that there was no zigzagness and pruning in the process.

Types may have their waywardness gradually sifted out of them. The uniformity of the flow of cartridges from a testing machine gives a fallacious impression unless we discover that they have passed through three siftings which reject the too heavy and the too light, the too long and the too short, and those whose calibre is too broad or too narrow.

On the other hand, one of the impressions that we get from Prof. D'Arcy Thompson's magistral work on *Growth and Form* is that the variability of organisms runs on lines laid down by the conditions of the inorganic. Variations must conform to the trammels of surface-tension, minimal areas, stability, and so on; there is not an indefinite number of ways in which an aggregate of cells can be arranged; one skull or leaf often differs from a related form in a way which might be described as a general deformation—due, for instance, to a tilting of axes. The same general impression of definiteness we get from considering what we have alluded to as temporal variations: one species often seems to differ from another in *rate* or tempo, and this fits in with Prof. D'Arcy Thompson's morphological illustrations, for differences of form depend in great part on different rates of growth in different directions.

But even mutations and definite orthogenetic variations cannot dispense with the criticism of Natural Selection. There is ever a risk that they may go too far. It is easy to have too much of a good thing. The antlers of the Irish Elk which hastened the doom of their possessors are diagrams of the evolutionary adage *Nequid nimis.* If we accept De Vries's view that evolution is often effected by mutation, by sudden considerable jumps, this is contrary to the idea of Natural Selection working as an accumulator of small gains. But De Vries does not propose to dispense with the theory of Natural Selection. He attaches less importance to intra-specific selection, but not less to the sifting of species by one another and by the environment. Speaking of the Mutation-Theory, Prof. G. H. Parker writes (1913, p. 263): "Organic evolution, then, is accomplished by occasional strides rather than by many oft-repeated short steps. This theory is in no sense antagonistic to natural selection. In fact, it works effectively only in conjunction with natural selection, for, after all, what determines whether a race showing a trait produced as a mutation will survive or not is natural selection. . . . As De Vries himself rightly maintains, the mutation theory is significant only in connection with natural selection."

§ 5. *Scientific Critique of Selection Theory.*

As our whole view of Animate Nature is coloured by our position in regard to the scope and importance of the processes of selection, we must consider some of the most serious objections to the theory. We select three. One of the criticisms is thus clearly stated by Prof. G. H. Parker (1913, p. 256): "The chief objection that has been raised against natural selection is one which was well known to Darwin himself, but which has been gathering strength for some years past. It is to the effect that the initial phases of a favourable variation, as conceived by Darwin, are too slight to be of use to the organism, and consequently they cannot come under the influence of the selective process. When the slight individual differences that Darwin laid so much stress upon are closely scrutinised, it seems scarcely conceivable that they could be, even in the long run, of life-and-death importance to an organism; in other words, that they could afford a starting-point for the formation of a new species. And when closely related species in nature are examined, such as the different kinds of warblers, or of sedges, it seems impossible that the slight differences separating them should represent gaps produced by natural selection through an elimination of intermediate forms. Thus an inspection of nature reveals a state of affairs which many investigators have come to believe to be much too refined to be a product of natural selection." Some who admit that natural selection is "capable of rough-hewing a species" doubt its ability to put on "the polishing touches". The answers to this objection are three. (1) The idea that established differences between species are too refined to be the work of natural selection, shows a lack of appreciation of the fact that the selection is often in relation to a very intricate and subtle web of life, where the shibboleth that decides survival or failure may be a very refined criterion indeed. (2) Variations are sometimes correlated, and a minor variation which is not itself of sufficient magnitude to have survival value may be carried in the wake of one that has. (3) Some variations are not minute fluctuations, but are brusque mutations, springing fully formed into existence and therefore at once of a magnitude to be sifted in the sieves of natural selection.

A second objection, also familiar to Darwin, is that individuals possessing an advantageous variation would have to pair with others not possessing it, and that the new departure would be swamped by the inter-crossing. To this there are three answers: that similar variations often occur about the same time in several individuals; that many factors of isolation operate towards reducing the range of inter-crossing and bringing similar forms together; and, thirdly, that many variations are of the nature called Mendelian, which do not blend, but are handed on in intactness to a certain proportion of the descendants.

A third even more serious criticism has arisen out of the recent selection-experiments of the Danish biologist Johannsen, the Dutch botanist De Vries, the American zoologists Jennings and Pearl, and others, which are to some extent at variance with the Darwinian view, that the average of a stock can be improved as regards a particular character by always breeding from those that show most of it. If the descendants of an individual high-class bean are kept apart, forming what is called "a pure line", there are observable fluctuations of characters. Some are tall plants, others are short, and so on. But if the talls are selected out and bred from, or the shorts, there is no establishment of a tall race, getting gradually taller, or of a short race getting gradually shorter, nor is there anything to choose between the descendants of the talls and the descendants of the shorts. There is no departure from the average of the original pure line. From a mixed wild stock a selection may be made of particular types which start pure lines or distinct races, but when the pure line has been started there is no further progress, select as one may. There is no getting beyond the mean of the inbred line. The reason for this seems to be that the fluctuations within the pure or inbred line are modifications or indents, and not transmissible.

If selection of the best of a pure line does not improve the stock, how do the breeders succeed? The answer is that their success is due to making a good start with a good line; beyond the level of this they cannot pass without the introduction of fresh blood from another line. There are obvious reasons, however, why these facts from artificial selection must not be used hurriedly in depreciation of the rôle of selection in natural wild conditions. (*a*) Pure or inbred lines are not typical of wild stocks, in which cross-fertilisation is of frequent occurrence. (*b*) It is dangerous to argue from very short-lived experiments to the age-long processes of Nature. (*c*) It is premature to deny the possibility of stable germinal variations occurring in a pure or inbred line. If one did, it might be the starting-point of a new advance. In any case there remains a great rôle for Natural Selection in eliminating certain lines or races and favouring others in its ceaseless sifting.

§ 6. *Subtlety of Selection Theory.*

Natural Selection is a technical expression for a manifold and almost ubiquitous process of sifting, which discriminates in life and in death between the relatively more fit to the given conditions and the relatively less fit. It must always be thought of in the Here and Now, *i.e.,* in reference to particular conditions of space and time. There are three reasons why it is important to keep this obvious fact in view. (*a*) It is a frequent and pernicious error to suppose that there is any sort of ceaseless winnowing towards an ideal of fitness, except perhaps self-consistency. The only common character of surviving variants is that they survive,—they must have consistent viable constitutions suited to particular conditions, which may be those of parasitism or putridity. The fallacy of supposing that Natural Selection necessarily works towards ‘ fitness ’ in the colloquial sense is largely due to thinking of the process abstractly and hypostatising it, and to misunderstanding the word ‘ fit ’, which means merely relatively advantageous in given conditions, making for survival in short. But the error is also due to a shrewd perception of the big fact that, after all, *life has been slowly creeping upwards* as the ages have come and gone. We shall consider this fact later on, but meanwhile it is necessary to be perfectly clear that being selected does not necessarily confer on the creature any dignity or approval. It means wholly and solely survivability in certain conditions, which may be those of parasitism or sloth. The value of survival, as judged by any human standard, depends altogether on the conditions under which survival is secured. Survival may be to a type that does not work for its living, but is an unpaying boarder inside another creature, or to a mere drifter in the stream of things, or to a rough egoistic combative type, much less desirable, when judged by æsthetic or ethical standards, than a gentle, altruistic, fine-brained type for which the times were too stern. Survivability means little in itself: one has to know the regional conditions and the price paid.

(*b*) It is important, for a second reason, to remember that Natural Selection operates in great part with an external reference to an established system of inter-relations which we call the web of life. For it is this reference to an intricate sieve that enables us to understand how minute and rather subtle advances might have survival-value, or might turn the scale between success and failure. A *nuance*—a shibboleth—may be decisive. There are some kinds of fresh-water mussel which cannot continue their kind without the unconscious co-operation of a particular species of fresh-water fish. The parasite which causes the disease of liver-rot in sheep cannot in Britain continue its race unless the free-swimming larva find entrance to a particular species of fresh-water snail *Limnœa truncatula,* for other species do not seem to serve. There are some flowers which cannot be pollinated except by a particular kind of insect-visitor. We miss the significance of Natural Selection unless we realise its frequent specificity. Meredith speaks of Nature winnowing " roughly ", and that may sometimes be; but it is also a fact that she often winnows with a meticulous nicety.

To sum up. In variation and selection we have, so far as we know, the chief factors of Animate Evolution. The method is theoretically very simple. A move is made and it is tested; a new idea occurs and it is criticised. But this kind of formal summary of the tactics is quite fallacious. It conceals the heart of the matter, that living creatures with a will to live, with an insurgent self-assertiveness, with a spirit of adventure, with an endeavour after well-being—it is impossible to exaggerate the personal aspect of the facts, even if the words which we use in our ignorance may be too metaphorical—do trade with time and have commerce with circumstance, as genuine agents, sharing in their own evolution. There is abundant room for sympathetic admiration of the tactics of Animate Nature, though the strategy may —and, for science, must—remain obscure.

§ 7. *Sexual Selection.*

(*a*) To illustrate still further the subtlety of the process of Selection we shall now consider how it works in the case of preferential mating. It was primarily in reference to secondary sex-characters that Darwin suggested his theory of sexual selection. Certain variations, *e.g.,* in the improvement of weapons and food-catching apparatus, are favoured by natural selection in the course of the everyday struggle for existence; in the same way, variations which are advantageous in securing mates and consummating sexual reproduction will be favoured by sexual selection. Darwin began with instances of the importance of masculine vigour and equipment when rival males compete for the possession of the females. "The strongest and, with some species, the best-armed of the males drive away the weaker; and the former would then unite with the more vigorous and better-nourished females, because they are the first to breed. Such vigorous pairs would surely rear a larger number of offspring than the retarded females, which would be compelled to unite with the conquered and less powerful males, supposing the sexes to be numerically equal; and this is all that is wanted to add, in the course of successive generations, to the size, strength, and courage of the males, or to improve their weapons" (*Descent of Man,* 2nd Ed., 1888, Vol. I., p. 329). Now it is plain that forceful competition among rival males for the possession of a female or of several females, does not differ in kind from the ordinary struggle for food and foothold, except that it is strictly intra-specific. Darwin pointed out indeed (p. 349) that sexual selection is less rigorous than natural selection; that it is less of a life-and-death affair; that it operates through the unsuccessful males having fewer, less vigorous, or no offspring; and that it is not limited by the general conditions of life; but there is in all this no departure from the natural selection position. This part of the theory, therefore, remains valid to those who regard natural selection as a *vera causa.*

(*b*) Darwin went on to those characters that are useful in the recognition and capture of the females. When a male excels his neighbours in his capacities for finding, pursuing, and catching the female, sexual selection, he said, again comes into action. (*Descent of Man,* p. 324.) The male moth often finds his mate by the olfactory acuteness of his large antennæ; some small crustaceans recognise the other sex almost instantaneously when there is chance contact in the water; in some fishes, recognition depends on colour and on behaviour; many experiments led Goltz to believe that the male frog distinguishes the female by touch; in birds, visual and auditory impressions count for most; in mammals, the scent is often of chief importance (see S. J. Holmes, *Studies in Animal Behaviour,* Boston, 1916, pp. 219-328). Since correct recognition of the one sex by the other is often of essential importance to the race, it is not surprising to find Darwin saying (*Descent of Man,* p. 324): "But in most cases of this kind it is impossible to distinguish between the effects of natural and sexual selection." This part of the theory also remains valid, if one believes in selection at all.

(*c*) Darwin primarily used the term sexual selection for all cases where sifting occurs in relation not to ordinary nutrition and self-preservation, but to pairing. It was only secondarily that he laid emphasis on the 'choice' that the female is supposed to exercise in reference to rival suitors. An interesting confusion, which has misled some biologists, has arisen by a double use of the word selection. Darwin spoke of the female's selection, but it is perfectly clear that he recognised a large field of selection in which there was no question of selection or choice on the part of the female. (See *Descent of Man,* 2nd Ed., 1888, Vol. I., p. 323, footnote.) Sexual selection meant, for Darwin, sifting in connection with mating, whether the female held the sieve or not.

(*d*) In his next step Darwin used the word selection in a non-metaphorical sense:—"Just as man can give beauty, according to his standard of taste, to his male poultry, or more strictly can modify the beauty originally acquired by the parent species, . . . so it appears that female birds in a state of nature have, by a long selection of the more attractive males, added to their beauty or other attractive qualities" (*Descent of Man,* 2nd Ed., 1888, Vol. I., p. 326). In many animals, at diverse levels of organisation, there is an elaborate courtship-ceremonial, allied, according to Groos, to play. It is sometimes on both sides; it is usually for the most part on the male's side. It includes a manifold display of decorations, colours, agility, and vocal powers. Darwin's theory in this connection was simply this: if there are rival males, and if they are unequally endowed with structural and emotional equipment, or with the capacity of using this to advantage, there will be preferential mating on the female's part, and, other things equal, there will be a selection of the type of male most successful as a suitor. It is the female who sifts, but the logic of the process is the same as in natural selection.

(*e*) It is conceivable that pronounced and persistent differential mating might lead not merely to the establishment and augmentation of characters determining the result of the contest or the courtship, but also to a process of physiological and psychological 'isolation' (narrowing of the range of inter-crossing), and thus to an accentuation of the apartness of a species as regards crossing with related neighbour-species (see Karl Pearson, *Grammar of Science,* 2nd Ed., 1900, p. 418).

(*f*) At this point attention may be directed to the important contributions to the natural history of mating to be found in H. Eliot Howard's monumental *British Warblers* (1907-1915). We venture to think that this acute and sympathetic observer exaggerates the instinctive at the expense of the intelligent element in the behaviour of birds, and that he is unnecessarily antagonistic to Darwin's theory of sexual selection, but his work is a rich treasure-house of reliable data. It is of great interest, for instance, to discover how much competition there is among the male warblers, before the females arrive on the scene, in the way of discovering and securely holding the most advantageous territories for nesting. Not less important is the evidence that the soberly coloured warblers do not fall behind brilliantly coloured birds in the elaborateness and abandon of their display attitudes and poses.

(*g*) Darwin was well aware of many of the difficulties besetting his theory. With his wonted candour he anticipated various objections, *e.g.,* that the theory "implies powers of discrimination and taste on the part of the female which at first appear extremely improbable" (*Descent of Man,* p. 326). The first very serious criticism came from Wallace in 1871, and was restated in his *Darwinism* in 1889. The most elaborate criticism as yet is surely to be found in T. H. Morgan's *Evolution and Adaptation* (1903), where no fewer than 24 reasons are given for rejecting the theory. Within our narrow limits we must confine our attention to the three criticisms which seem most important.

There is, in the first place, an admitted difficulty in the scarcity of direct evidence that some of the males are actually disqualified and left unmated. If all the males get mates sooner or later, then no discriminate elimination is effected. Prof. Karl Pearson has given statistical evidence of preferential mating in mankind, but this is hardly procurable in the animal world. Darwin met the objection in various ways. He pointed out that in some species the males outnumber the females, and that in some other species there is polygamy. If the more attractive males have in such cases an advantage in mating, the direction of evolutionary movement will be determined by them, and not by the handicapped residue of the unattractive. He also pointed out that the more vigorous and more attractive males would be accepted by the more vigorous females which are the first to breed, and this would imply a cumulative preponderance of the more vigorous and more attractive types. Even earlier hatching of the young birds might be of critical moment. As a matter of fact, definite information as to the elimination of some of the males is by no means wholly lacking. Thus in diagrammatic illustration we may refer to some spiders where, as the Peckhams and others have shown, the female sometimes kills a suitor who does not adequately please her. That she may also kill a successful suitor is immaterial, since the mating has been accomplished. (See G. W. and E. G. Peckham, *Observations on Sexual Selection in Spiders of the Family Attidæ,* Milwaukee, 1889, p. 60.)

In the second place, many critics have objected to crediting the female organism—whether bird or butterfly—with the power of 'choice', and while comparative psychology has not advanced far enough to admit of many definite statements as to the subjective aspect of animal courtship, it may be granted that there is not in the 'choice' of any female animal much that would correspond to a human weighing of pros and cons. But the point of importance is whether the mating is in any real way selective, preferential, discriminative. It has been proved experimentally that insects as well as birds may be selective in their eating: is the same true as regards their mating? It appears to us that the phenomena of mating recorded by Darwin, by Groos (*Play of Animals,* 1898), by Cunningham (*Sexual Dimorphism,* 1900), by Pycraft (*Courtship of Animals,* 1913), and so on, place the reality of some measure of preferential mating beyond doubt. Even if one adopts the modern view that the female does not choose the 'best' out of a bunch of suitors, but rather remains unresponsive to the solicitations of males who do not raise her emotional interest to the requisite pitch, that is quite enough for the purposes of the theory; and it is in agreement with Darwin's own remark about the female bird: "it is not probable that she consciously deliberates: but she is most excited or attracted by the most beautiful, or melodious, or gallant males".

A third objection is more serious. It is one thing to admit the reality of a somewhat vague preferential mating, it is quite another thing to credit the female animal with a capacity for appreciating slight differences in decorativeness or musical talent or lithesomeness. Wallace's statement of this objection is well known. Referring to Darwin's four chapters in *The Descent of Man,* he says: "Any one who reads these most interesting chapters will admit that the fact of display is demonstrated; and it may also be admitted, as highly probable, that the female is pleased or excited by the display. But it by no means follows that slight differences in the shape, pattern, or colours of the ornamental plumes are what lead a female to give the preference to one male over another; still less that all the females of a species, or the great majority of them, over a wide area of country, and for many successive generations, prefer exactly the same modification of the colour or ornament (*Darwinism,* 1899, p. 285).

But the edge has been taken off this objection by Lloyd Morgan and others, who point out the gratuitousness of crediting the hen bird with a standard of taste or capacity for æsthetic valuation. "The chick selects the worm that excites the strongest impulse to pick it up and eat it. So, too, the hen selects that mate which by his song or otherwise excites in greatest degree the mating impulse. Stripped of all its unnecessary æsthetic surplusage, the hypothesis of sexual selection suggests that the accepted mate is the one that most strongly evokes the pairing instinct" (*Habit and Instinct,* 1896, p. 217).

It may be insisted, however, that if individual excellence in attractive characters (such as plumes, singing power, dancing agility) does not appeal to the female, it cannot be determinative in preferential mating, and therefore its establishment cannot be effected by any process of sexual selection. Unless the female is somehow aware of the individual variation in question, the theory breaks down, and yet it is difficult to believe that the female is so meticulous in fastidiousness, so detailed in her preferential excitability.

The answer, probably sound, is that the details count, not as such, but as contributory to a general impression. Each has its effect, but synthetically, not analytically. "Even when the female seems to choose some slight improvement in colour or song or dance, the probability is that she is simply surrendering herself to the male whose *tout ensemble* has most successfully excited her sexual interest" (Geddes and Thomson, *Evolution,* 1911, p. 172).

(*h*) If one provisionally accepts the theory that a secondary sex-character may have been established and augmented because it contributed to a decision in preferential mating, one has to face the further question of the significance or racial justification of the courtship-habits—often so prolonged, elaborate, and exhausting. The sifting probably works well in keeping up a standard of racial fitness, for the most persuasive male is likely to be, among animals, the fittest all round. But there is surely more than this.

To Groos and to Julian S. Huxley we owe two luminous suggestions. In his *Play of Animals* (Eng. Trans., 1898, p. 242), Groos suggests that "in order to preserve the species the discharge of the sexual function must be rendered difficult, since the impulse to it is so powerful that without some such arrest it might easily become prejudicial to that end". "This very strength of impulse is itself necessary to the preservation of the species; but, on the other hand, dams must be opposed to the impetuous stream, lest the impulse expend itself before it is made effectual, or the mothers of the race be robbed of their strength, to the detriment of their offspring." . . . "The most important factor in maintaining this necessary check is the coyness of the female; coquetry is the conflict between natural impulse and coyness, and the male's part is to overcome the latter" (*op. cit.*, p. 243).

Not less interesting is the suggestion developed by Julian S. Huxley in his remarkable study of the courtship-habits of the Great Crested Grebe, *Podiceps cristatus* (Proc. Zool. Soc. London, 1914, pp. 491-562). In the Great Crested Grebe the two sexes are practically alike in plumage, colour, and habits; but the courtship is extraordinarily elaborate—a self-exhausting ritual, "not leading up to or connected with coition". Mr. Huxley believes that "the courtship ceremonies serve to keep the two birds of a pair together, and to keep them constant to each other". "Birds have obviously got to a pitch where their psychological states play an important part in their lives. Thus, if a method is to be devised for keeping two birds together, provision will have to be made for an interplay of consciousness or emotion between them." The courtship is justified by the strength of the emotional bond it establishes. There is a "Mutual

Selection" which is in a way "a blend between Sexual and Natural Selection".

(*i*) A survey of recent observations on mating, as in Mr. W. P. Pycraft's *Courtship of Animals* (1913), leaves an impression of an intricacy and subtlety that baffles description. We agree with this distinguished expert as to the need for *psychological* as well as physiological interpretation. It is probable that no naturalist has studied a courtship with the thoroughness that Mr. Huxley shows in his account of the Great Crested Grebe, and what is his verdict? "Display and ornament do not act on the æsthetic sense of the female, but on her emotional state; they are—using the words in no narrow or unpleasant sense—excitants, aphrodisiacs, serving to raise the female into that state of exaltation and emotion when alone she will be ready to pair. . . . But the element of choice does, in another form, remain. In animals such as Birds, where there is a regular pairing-up season, and where, too, the mental processes are already of considerable complexity, it is impossible to doubt but that mating may be, and in some species is, guided by impulse, unanalysable fancies, individual predilection."

(*j*) In his *Studies in Animal Behaviour* (1916) Mr. S. J. Holmes has an interesting chapter on "the rôle of sex in the evolution of mind". Let us take one illustration. "The primary function of the vocal apparatus of the Vertebrates was probably to furnish a sex call, as is now its exclusive function in the Amphibia. Only later and secondarily did the voice come to be employed in protecting and fostering the young, and as a means of social communication. And the evolution of the voice in Vertebrates doubtless influenced to a marked degree the evolution of the sense of hearing. It is not improbable, therefore, that the evolution of the voice, with all its tremendous consequences in regard to the evolution of mind, is an outgrowth of the differentiation of sex." There can be little doubt that the biology of the future will attach not less but more importance to sexual selection. For it seems likely that characters and qualities originally established in this way have often influenced both body and behaviour in reaches now more or less remote from the tides of sex-impulses.

§ 8. *Selection and Progressiveness.*

There is a very important reason why we should keep in mind the relation of Natural Selection to the Systema Naturæ which has been gradually evolved, which is continually becoming more complex, which is made up of numerous components, mostly stable and beautiful, often intelligent and purposeful. The reason is that we have here part of the explanation of the progressiveness of evolution. For, while there are blind alleys and other paths that turn back on themselves, the large fact is that on the whole evolution has been in the direction of increased differentiation and integration, of growing mastery and freedom. In this way Nature has led up to Man, her minister and interpreter. But *how* was it effected?

It may be that part of the secret is insoluble, that it is wrapped up with a tendency to complexify which may be seen even in the inorganic, where corpuscles form atoms and these molecules, where small molecules form large ones, and large molecules colloid masses, and so on. *A fortiori* it may be inherent in the very nature of an organism to complexify, to differentiate.

We could suggest, however, that part of the riddle is solved when we carefully observe the process of Natural

Selection, which operates in relation to an external Systema Naturæ, the building-up of which is the work of æons. As organisms evolved there was a *pari passu* complexifying of the web of life, and this extra-organismal registration worked towards conservation and towards further advance. For it is in relation to the external system that selection works.

In the evolution of human societies much has always depended on the external registration of ideas and ideals. They form a framework of institutions and organisations, as stable as folk-ways and traditions; they become immortal in literature and art; and this extra-organismal registration works both towards conservation and towards further advance. For it is in relation to the external system that selection works. It may be urged, however, that the social system is often unsound, that it may give fixed expression to the vicious as well as to what is noble, and that the result is to help degeneration not progressive evolution. The answer is sadly familiar, that this does occur; and that nationalities and their monuments alike are then swept from the stage.

The difference in the realm of organisms is that we have there to deal with an external system which is the product of many millions of years, that the disintegrative elements which entered into it have for inherent reasons failed to stand the test of time. Like rotten stones in a building they have crumbled away. But they have been replaced by others more enduring.

What we mean may be made clearer by a concrete instance. It was probably in the Carboniferous age that various insects became flower-visitors, that inter-relations began to be established between insects and flowers, between flowers and insects. The flowers evolving in their own way came to have flower-visiting insects (likewise evolving) as part of their environment, as part of the system in relation to which they were naturally selected. Similarly with the insects in relation to 'entomophilous' flowers. And as the inter-relations became more and more intricate, more and more precise, they would tend to make the selection progressive.

There may be a sort of momentum in the organism itself, for nothing succeeds like success. As Walt Whitman wisely said, "It is provided in the essence of things that from any fruition of success, no matter what, shall come forth something to make a greater struggle necessary." As was said of old time: "For to every one who has shall more be given and richly given; but from him who has nothing, even that which he has shall be taken." Organisms run on a compound interest principle. But our present point is that the external web of life becoming ever more complex will tend to secure progressiveness.

Whether or not our idea means as much as we think it does, its consideration should in any case put an end to the notion that Natural Selection is capricious. Both as regards the raw materials and the sieve, evolution is very far removed from being 'a chapter of accidents'.

§ 9. *Selectionist Interpretations and the Argument from Design.*

This seems the appropriate place for a consideration of what has been called the Argument from Design. Discovering some of the thousand-and-one ways in which the structure and function of organisms are fit for the conditions of life, many keen-sighted and reverent naturalists of older days argued directly from the adaptations to the agency of a Divine Adapter. It was in a way a wholesome attitude, for the abundance of adaptations is a prominent fact in the realm of organisms; they have, as Mr. Balfour says, "exquisite nicety and amazing complexity"; they are not *easily* accounted for; and some of them make for the continuance of what has for Man great value. But it can hardly be maintained that the argument in its old form was logically sound. As Professor Lovejoy puts it (1909), "from knowing, through experience, that certain effects are caused only by purposive human agency, we have no ground whatever for concluding that certain other effects, of whose causation we have no experience at all, must be due to non-human purposive agency". It has been called by logicians the *fallacy* of transcendent inference, but perhaps there is a *truth* of transcendent inference in the idea behind the argument.

Many naturalists know and admire three monumental volumes by the late Prof. Bell Pettigrew entitled *Design in Nature* (1908). They form a magnificent, generously illustrated treasury of adaptations. But not the least interesting thing about these volumes is the fact that the author, with the thousand-and-one fitnesses before him, found himself forced, like Darwin, to abandon the position of the Bridgewater Treatises, that one may find in adaptations the evidence of Divine Design. There is no doubt as to the reality of the thousand-and-one adaptations: Why is the Bridgewater Treatise position untenable?

(1) It is a curious characteristic of some minds that they cannot give a living creature credit for doing anything very wonderful. They refuse to contemplate the possibility that what the creature does may be accounted for in terms of itself. They insist on helping the organism on by some extraneous introduction—an Entelechy, a Purpose in Nature, an *élan vital,* a Directive Intelligence, and so forth. What the older Naturalists should have done before concluding

their argument was to inquire how far the intelligence, which adaptations certainly suggest, may be resident as intelligence or some analogous form in the creatures themselves. Modern study shows that many animals work out their own salvation.

(2) The second reason why modern naturalists do not occupy the old position is because their outlook is evolutionist. When they scrutinise the magnificent series of adaptations more closely they discern less perfect stages of them in antecedent forms of life. The eye of a fly is an extraordinary instrument, but there is a long ladder of eyes approximating to it. The community of hive-bees or of social wasps amazes us—at first almost bewilders us,—with its complexity and subtlety, but there is a long series of gradations connecting it with the life of solitary bees and wasps. Moreover, as we look around, we see that many adaptations are still in progress, and very far from perfect.

(3) The third reason is, that, given a sufficient crop of variations, plenty of time, and a process of sifting, the Darwinian can give a plausible and approximate—we do not say an easy or complete—account of the way in which most of the wonderful adaptations have been evolved. The hard-shelled Darwinian says: These effective adaptations you so justly admire are the outcome of natural tentatives and natural siftings. We assume that the forms of life are restlessly but not inconsistently variable, that they are continually offering new qualities and characters to the sieve of selection, and that the conditions of life are such that they eliminate in a very discriminating fashion the relatively less fit. If these assumptions are granted, we can account for adaptations. The immediate operation of a Divine Adapter is a hypothesis of which, we say it with the utmost reverence, we cannot scientifically make any use.

The idea of a Divine Designer is outside the scientific mode of formulation, to which it is an impiety not to be loyal, but it is not outside the right of interpretation which we claim as rational beings. It is a religious idea—this of the Divine Designer; the question is whether it is inconsistent with securely established scientific thinking. In our judgment it is not inconsistent.

The old form of the Argument from Design has no longer more than a historical interest, but it may be reasonably maintained, it seems to us, that the general idea behind the argument remains. For if we free ourselves, as we think we must, from a purely mechanical evolutionism, and recognise organisms as genuine agents, we may see in the factors of evolution the relatively, though, of course, not absolutely self-sufficient, means of working out a purpose, or thought, or idea which was involved by the Creator in the origination of the first organisms, or wherever it seems clearest to begin. We must not forget the problem of the origin of the conditions that made Organic Evolution possible. That He—the Unmoved Prime Mover—has made things to make themselves and to go on perfecting themselves—albeit they may be never separable in thought from Him—seems a finer kind of creation than Paley pictures. As Professor Pettigrew said in his *Design in Nature* (p. 820), "Natural Selection may be regarded merely as a process of so-called evolution by which the Creator works and accomplishes His purpose. Indeed the Creator, by conferring upon living matter in its simplest and lowest forms the power of appropriating the elements and building them up by endless elaboration and gradation from a monad to a man, proves Himself to be an infinitely more wonderful Designer than was ever dreamt of by even the most ardent teleologist." This surely strikes the true note.

But it must be noted that it would not occur to scientific investigators, as such, to speak of the factors of evolution as *means* to an end. That is a point of view beyond science, though naturally taken by those who feel the extraordinary value and significance of certain results of evolution,—such as the beauty of Nature, or the moving equilibrium of things, or the progressiveness of organisation, or the emancipation of mind, or the incomparable worth of a noble human life.

SUMMARY.

The central idea in Darwinism is the selection of the relatively fitter variants in the struggle for existence.

An immediate logical recoil from Darwinism has been based on the fact that Natural Selection is not originative, only directive; and that it is rather eliminative than selective. But these points are freely admitted by Darwinians; the recoil is due to a misunderstanding of insufficiently criticised phraseology.

A sentimental recoil from Darwinism has been based on the supposed mechanical character of the selective process (but many organisms share as agents in their own evolution), and on the supposed grimness of the eliminative methods (but this is a very partial view).

Since Darwin's day the theory of Selection has undergone some modification. Its position has been strengthened by the demonstration of several cases of Natural Selection at work, by actual proof of a differential death-rate. It is not a mere interpretative hypothesis. Its position has been strengthened by a recognition of the manifoldness of the selective processes, *e.g.*, lethal and reproductive. There has also been a clearer view of the probable consequences, *e.g.*, exuberant decorativeness, that may ensue in situations where the elimination has been greatly relaxed. The estimate of the scope of Natural Selection is affected by the view taken in regard to the raw materials supplied. If these reach by mutational abruptness to some degree of perfectness, there is little for Natural Selection to do in the way of accumulating minutiæ. If they are in large measure definite, then Natural Selection has not to sift out the serviceable from a large casual crop. It

has been shown by Johannsen, de Vries, Jennings, Pearl, and others that selection does not count for much within pure-lines or inbred stocks. The abundant 'fluctuations' that occur there cannot be used as a basis for selection, for they are not transmissible, and are probably for the most part of the nature of modifications.

As our whole view of Animate Nature is coloured by our estimate of the validity and importance of the Selection-Theory, it is useful to consider some of the more serious criticisms, *e.g.*, that slight initial changes could not have survival value, that they would be swamped or levelled down by inter-crossing. . . . It does not seem too much to say that the theory survives these criticisms and has been the better for them.

It is very important to recognise that Natural Selection is a technical expression for a manifold, almost ubiquitous, and often subtle process of sifting, which has, in most cases, a particular reference to particular conditions in time and space. It does not work consistently towards an ideal of fitness, but it eliminates inconsistent non-viable constitutions; it often operates in reference to an intricate web of life, and thus a *nuance*—a shibboleth—may have survival value; it operates, generally speaking, in relation to a Systema Naturæ which has been increasingly elaborated through the ages, in which even ideas and affection get embodied, and this is part of the explanation of the progressiveness of evolution. Another part of the explanation of the progressiveness, which has always been a puzzle except to teleological interpretation, is what may be called organismal momentum. Organisms run on a compound interest principle.

The question rises again whether the operative factors in organic evolution are more than complications or compositions of factors which operate in inorganic genesis. The answer is, much more. Natural Selection operates on what is not accounted for mechanically, and the sifting process itself is more than mechanical. What Ward has shown in regard to Subjective Selection is vitally important to an accurate view of the facts. The same conclusion may be reached from a different set of data, the phenomena of preferential mating.

In variation and selection we have, so far as we know, the chief tactics of Animate Evolution. A move is made and it is tested; a new idea occurs and it is criticised. But a formal statement of the tactics is fallacious. It conceals the heart of the matter, that living creatures with a will to live, with an insurgent self-assertiveness, with a spirit of adventure, with an endeavour after well-being —it is impossible to exaggerate the facts, even if the verbal suggestion is in our ignorance too metaphorical—do trade with time and have commerce with circumstance as genuine agents, sharing in their own evolution. This should at least increase our sympathetic admiration of the tactics of Animate Nature, though the strategy remain obscure.

Science has to do with description and formulation—not with interpretation. Thus the selectionist account of the evolution of adaptations does not conflict with the general idea behind the old 'argument from design'.

LECTURE XV.

THE INDIVIDUAL AND THE RACE: HEREDITY.

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§ 1. *Definition of Heredity, Inheritance, Nurture, Development.* § 2. *Heredity a Condition of Evolution.* § 3. *Modifications and Heredity.* § 4. *The Organism as a Historic Being.* § 5. *Nature and Nurture.* § 6. *The Other Side of Heredity.* § 7. *Heredity and Personality.*

THE water-vapour in the atmosphere condenses into rain which falls on the hills; in the cold night it is changed into ice, and next morning into running water again; at midday it changes once more into water-vapour. So the same material in the domain of the inorganic passes from form to form, and nothing is lost. A mineral changes into something else and great aggregates are slowly transformed. "They say the solid earth on which we tread in tracts of fluent heat began." There is a similar sort of flux in the realm of organisms, in everyday metabolism, in wear and tear, in senescence. "And so from hour to hour we ripe and ripe, and then from hour to hour we rot and rot, and thereby hangs a tale."

But apart from remarkable cases like Uranium liberating Helium and giving origin to Radium, which liberating more Helium may give origin to Lead, there is nothing in the domain of things to compare with sequence of generations that marks the realm of organisms. Individuals grow old and die; oftener perhaps they do not grow old, but are devoured; in any case they give place to others in the production of which they often share. The corporeal individuality ceases to exist as such, yet part of it or something that was wrapped up with it continues, or may continue into another individuality. This is the genetic relation—heredity, which has to be considered as a condition of evolution, and likewise as a factor in determining the individual life.

§ 1. *Definition of Heredity, Inheritance, Nurture, Development.*

A few definitions, representing condensed discussions, may be useful to start with. Heredity is the relation of organic continuity between successive generations, which secures the general persistence of resemblance between offspring and their parents, between progeny and their ancestors; it implies the continuance of a specific dynamic organisation of which the germ-cells are usually the vehicle. In brief, heredity is the genetic relation between ancestors and descendants.

Some use the word heredity to include all the causes or factors which determine the resemblance between individuals who are related to one another. But this resemblance is not wholly due to heredity. Others would say that heredity is the fact that like begets like; but it is more than that, including indeed the possibility of variations. Others would say that heredity is the past living on in the present, but perhaps inheritance is the fitter word to denote that fact. All these definitions suggest part of the truth, but it seems clearest to regard heredity as the organic relation between successive generations,—a relation which secures persistence of characteristics and yet allows new ones to emerge.

Whatever definition of heredity is adopted, it must be clearly understood that heredity is no mysterious force or principle; it is a flesh-and-blood linkage, a continuity of germ-plasm, binding one generation to another. In pre-Darwinian days, men always spoke of heredity with a capital letter, as if it were a power that did things, as many people still talk of Evolution, but one of Darwin's many services was that he showed the linkage between generations to be amenable to scientific experiment and description.

In mankind one generation may influence its successors by tradition and institutions, by literature and art, and in similar ways which are outside heredity in the biological sense. For the extra-organismal legacies the term *social heritage* may be usefully restricted,—a usage which would leave Galton's term *natural inheritance* for all that is handed on by means of the germ-cells, namely the egg-cell and the sperm-cell. The natural inheritance includes all that the organism is or has to start with in virtue of its hereditary relation to parents and ancestors.

In most mammals, where the unborn offspring is carried by the mother for a more or less prolonged period—the two being bound together in a very intimate ante-natal partnership or symbiosis—the natural inheritance of the offspring may be influenced by peculiarities in the available maternal nurture. The same is true in all cases where the parents, plants as well as animals, nurture the offspring. It is plain, though often forgotten, that ante-natal dints or imprints are not in the strict sense part of the natural inheritance. The word nurture, which Galton raised to the rank of a technical term, includes all manner of extrinsic influences, environmental, nutritional, and functional, which play upon the organism, or with which the organism plays. Modifications, as we have seen, are structural changes in the body of the organism directly induced in the individual lifetime by peculiarities in function or environment (including food, etc.), which transcend the limit of organic elasticity and thus persist after the inducing conditions have ceased to operate. They may be illustrated by the tanning of the skin under a tropical sun, or by the fattening of cattle, or by a callosity due to pressure. They are dints due to peculiarities in nurture, and have not been convincingly shown to be transmissible as such or in any representative degree. Finally, it may be noted that development is the realisation of the normal inheritance in appropriate nurture.

§ 2. *Heredity a Condition of Evolution.*

Heredity is not so much a factor in evolution, as a condition of evolution. There would be heredity though there were no evolution, but there could be no evolution if there were not heredity. What is the rôle of Heredity?

(*a*) Heredity involves arrangements which secure the persistence of a specific dynamic organisation—holding fast that which is good. This rôle is achieved by a simple device—the continuity of the germ-plasm or essential germinal material, a luminous conception mainly due to Galton and Weismann. It amounts to this, that in the course of development, often very early, some germinal material containing the intact inheritance is kept apart from specialisation and goes to form the germ-cells which become the starting-points of another generation. As Galton pointed out, in development the bulk of the germinal material of the fertilised egg-cell goes to form the 'body' of the embryo, undergoing in a most puzzling way differentiation into nerve and muscle, blood, and bone; but a certain residue is kept apart from the development of the 'body' to form the primordium of the reproductive organs of the offspring, whence will be launched in due time another similar vessel on the adventurous voyage of life. Thus in a sense the child is as old as the parent, for when the parent is developing, a residue of unspecialised germinal material, retaining the heritable qualities in their intactness, is kept apart, and will eventually give rise to the germ-cells which form the starting-point of the child. As Weismann put it: In each development a portion of the specific germ-plasm contained in the parent egg-cell is not used up in the construction of the body of the offspring, but is reserved unchanged for the formation of the germ-cells of the following generation. So it comes to be that the parent is rather the trustee of the germ-plasm than the producer of the child. In a new sense the child is a chip of the old block. Or, as Bergson puts it, in less static metaphor, "life is like a current passing from germ to germ through the medium of a developed organism". It appears that too rigid a contrast has been made between body-cells and germ-cells; for groups of body-cells in plants, sponges, polyps, worms, Tunicates, and various other groups are able to develop into perfect organisms. It is safer to say that the germ-cells are those cells which carry the whole inheritance without allowing any of it to find expression until appropriate conditions and stimuli are forthcoming. They carry the whole inheritance in a form little liable to extrinsic influence and yet readily admitting of development. The general idea of germinal continuity is one of the most important contributions to post-Darwinian biology. It accounts for the inertia of the main mass of the inheritance, which is carried on with little change from generation to generation. For men do not gather grapes off thorns or figs off thistles. Similar material to start with; similar conditions in which to develop; *therefore* like begets like.

(*b*) The second rôle of the hereditary relation is that it allows of the emergence of the new and of the handing-on of the new. On the whole it makes for persistence, for inertia, but it also admits of the origin and entailment of novelties. An antithesis is often made between heredity and variation, but that is not well thought-out; the hereditary relation includes both the tendency to persistence and opportunities for variation; the antithesis is between the persistence of complete hereditary resemblance and the entailment of variations.

(*c*) The third rôle of the hereditary relation is to shelter the specific organisation from the influence of parental modifications. It is not certain that the shelter is quite complete; but it is indubitable that most of the dints made on the individual body are not entailed. An organism which becomes subjected to a lasting change of temperature may, as the direct result thereof, acquire some adaptive peculiarity of great advantage; it would please our idea of economy to know that this individual gain could be handed on. An organism forced into a new habitat changes its functions adaptively and acquires, as the direct result thereof, a new dexterity. It would please our idea of economy to know that this gain could be entailed. So far as we know, this does not occur, and the reason is probably that such entailment of gains would involve also an entailment of losses, and that both are inconsistent with the arrangements which secure what is much more important, namely, the persistence of the specific organisation and of the germinal changes which it from time to time exhibits. If any organisms ever showed a strong tendency to transmit somatic modifications, the probability is that they would be eliminated.

Our personal conviction, detailed evidence for which we have given elsewhere (*Heredity,* rev. ed., 1919), is that there is at present no good case warranting belief in the transmission of exogenous somatic modifications. But several biologists for whom we have the greatest respect think otherwise, and, without any indecision on our own part, we would refer to the works cited in the bibliography under the names of Hartog, MacBride, and Semon.

§ 3. *Modifications and Heredity.*

In the absence of any convincing evidence that exogenous modifications acquired by parents can be transmitted to their offspring, either as such or in any representative degree, we have to face the question whether individual modifications have any evolutionary interest at all. It may be answered, first, that deeply-saturating modifications may influence the blood and other fluids of the body, or may alter the rhythm of metabolism so that the production of internal secretions is affected, and that these internal changes in the somatic environment may act as liberating stimuli on the germ-plasm and provoke variations. Prolonged exercise, *e.g.*, in dancing, may lead to an exaggerated production of muscle-forming substance; the myogenic metabolism may be enhanced; this may be spread through the body, *e.g.*, from limbs to heart; it is conceivable that it might affect the germ-plasm specifically.

The second answer is that suggested by Profs. Mark Baldwin, Lloyd Morgan, and H. F. Osborn, that an adaptive modification may serve as a protective screen for the individual until, perhaps, a germinal variation in the same direction has time to arise and establish itself. What is not organically entailed may be acquired afresh in each successive generation. In an area where a dark skin was of survival value, acquired tanning might save many individual lives until, perhaps, a germinal variation in the direction of inborn swarthiness had time to appear and establish itself.

It seems to some quite incredible that the same modification should be hammered on for a thousand generations without inducing germinal changes in the same direction, but the difficulty is to find any direct or indirect evidence. It is likely enough that the long continuance of a particular modification might produce a metabolic change which might affect the germ-plasm, but the point is whether the effect on the germ-plasm would be to provoke a variation in the same direction as the modification. Mr. J. T. Cunningham and others have suggested that a well-defined modification may be followed by the liberation of some very specific hormone from the affected tissues, which might be carried to the germ-cells and there find a *nidus* for subsequent operations. But this remains a conceivable interpretation of what we do not know to be a fact.

(*c*) Another consideration must not be forgotten, that it is in the personal life of the creature that the germinal variations are expressed, used, and subjected to criticism. The germ-cell or implicit individuality determines the cards, but it is the developed organism that plays them. It is highly probable that the adult creature sometimes seeks out a situation where its idiosyncrasy tells. Prof. James Ward has emphasised the importance of this organic selection. Environment selects organisms, but an organism may also select its environment.

§ 4. *The Organism as a Historic Being.*

The central idea in heredity is the persistence of a specific organisation and the associated specific activity. The past lives on in the present. The category of organism includes the conception of the creature as a historic being. Let us think over this idea.

(*a*) There is, in the first place, the remarkable persistence of the main body of the inheritance, with but rare divergence. There is racial inertia; the entailment of what is called specificity. As was said of old time, "All flesh is not the same flesh: but there is one kind of flesh of men, another flesh of beasts, another of fishes, and another of birds." This is confirmed by modern research, which has demonstrated, for instance, that the ciliated epithelium lining the windpipe of a dog is different from that from a rabbit. A fish can often be identified from a few scales, a bird by a single feather. This specificity goes through and through: thus Reichert and Brown (1909) have shown that the various species of mammals, so far as they have been tried, differ in the minutiæ of their hæmoglobin crystals. In this way it is possible to distinguish the blood of a domestic dog from that of a wolf, or even from that of the Australian dingo; red fox, grey fox, and Arctic fox are crystallographically specific! Every creature has its own particular kind of colloidal substratum and its own particular chemical routine taking place therein. The largest fact of inheritance is the persistence of specificity, and we have here the reason why new departures of great moment are not likely to occur from specialised types. The relatively generalised types are most likely to be strikingly inventive.

The antiquity of the various parts of the hereditary framework is one of the most impressive facts of biology. Galton has used the illustration of modern buildings in Italy which have sometimes been built out of the pillaged edifices of ancient times; here is an antique column and there a lintel unified afresh.

(*b*) The persistence of antiques is often seen with diagrammatic vividness in the case of vestigial structures, which linger on in dwindled expression for ages after they have ceased to be of any use. As Darwin said, they are like the unsounded letters in many words, quite functionless but of historical interest. They have often been compared to the vestigial structures in clothes, buttons without corresponding holes, and holes without corresponding buttons. So is it with the deeply-buried remnants of the long lost hind limbs that some of the whales still exhibit, or with the minute comb-like vestige of a gill in the spiracle of a skate. The animal world is full of these interesting relics as if the past were loath to relinquish its lien on the present. Man is an antiquarian in spite of himself, a walking museum of relics. A good instance is the vestigial third eyelid, larger in some races than others, occasionally with a supporting cartilage, but quite useless. It is the remnant of the nictitating membrane that in most birds and mammals does important work in cleaning the eye. Similarly, the muscle which moves the trumpet or pinna of the ear in many mammals, such as dog and donkey, and is useful in locating sounds, is vestigial in man, who moves his head about so readily. Some men have it larger than others; some may even become able to move their ears by wasting attention on the senseless effort. It may be noted that there is no great evidence of imperfection in the fact that vestigial organs are sometimes troublesome; it is too much to expect that there should be no tax on the stability of what is useful.

Another instance of the past living on in the present is to be found in the persistence of ancient habits that have outlived their utility. According to Darwin, there is an echo of the distant past when the dog before it settles itself to sleep turns round and round in the imaginary herbage of the hearthrug. The hand of the past is upon it in the passivity of sleepiness, and it does needlessly what its ancestors did to a purpose. So in the donkey "we see signs of its original desert life in its strong dislike to cross the smallest stream of water". We are told that some Scottish cows transported to unwonted conditions on an American ranch hid their calves in the thicket, and went to feed in the open in the old approved fashion of wild cattle. The novel circumstances were really primitive and they awakened a long dormant instinct. Many examples of this sort have been collected by Robinson in his *Wild Traits in Tame Animals,* and while there is need for criticism, there can be no doubt as to the persistence with which the past lives on in the present. Many outcrops that seem quite perplexing in man are probably anachronistic stirrings of ancestral habits.

(*c*) Another set of illustrations of the past living on in the present is afforded by the facts that are now familiar in regard to the staying power of certain unit-characters or Mendelian characters that are relatively superficial in nature, and cannot be regarded as forming part of the main framework of the inheritance. When we consider how the Hapsburg lip has persisted for four centuries in Austria and Spain, how night-blindness has continued to crop out for ten generations and in hundreds of individuals in one family history beginning with 1637, or how brachydactylism (having the fingers all thumbs) may last for six generations, we realise that the hand of the past is living indeed,—and inexorable. We have already mentioned the laciniate variety of the Greater Celandine (*Chelidonium majus*), which suddenly appeared about 1590 and has been breeding true ever since, and it is this sort of fact that we must include in our conception of the living organism, of Animate Nature, and of man in particular. That the innate defects as well as the excellences of the fathers are continued in the children far beyond the third and fourth generation is well known.

(*d*) Another general illustration of the past living on in the present is to be found in the way in which the individual development tends to recapitulate the racial evolution. Long before the evolution idea was accepted, the suggestion was made, *e.g.,* by Meckel, von Baer, and Louis Agassiz, that the stages in individual development correspond to grades of organisation in the animal kingdom. In post-Darwinian days, Haeckel recognised the importance of the recapitulation doctrine and stated it clearly in the light of evolution. He called it the fundamental law of biogenesis, and stated it in the familiar words: "Ontogeny is a recapitulation of Phylogeny." He also emphasised the contrast between palingenetic characters, which correspond to those of the ancestral stock, and kainogenetic characters, which are relatively recent additions. The latter, he said, may disguise the former in a perplexing way; in any case, the recapitulation is general, not exact, and often shows great condensation. Fritz Müller was another who did much to illustrate and corroborate the recapitulation-idea, *e.g.,* in his *Für Darwin* (1864).

The recapitulation doctrine has suffered considerably at the hands of its friends, who have sometimes stated it in an exaggerated fashion. When Prof. Milnes Marshal said, "Every animal in its own development repeats its history, climbs up its own genealogical tree", he was speaking picturesquely, for the recapitulation is general, not detailed; it often shows telescoping; and it is truer of stages in organogenesis than of stages in the development of the embryo as a whole.

It has also to be remembered that one term in the comparison, the phylogeny, is very imperfectly known, so that assertions as to the exactness of the recapitulation must be taken with reserve. Needless to say, one must beware of the vicious circle of arguing from the development to the presumed ancestor, and then from the ancestor to its recapitulative rehabilitation in development.

Another saving clause is that the individual development, especially when there are larval stages, may have its recapitulatory features obscured by secondary adaptations to relatively recent conditions of life. Thus one does not look for recapitulation in the life-history of insects which have sub-aquatic larvæ, for these have been secondarily adapted to a habitat which was not that of the ancestral stock. We may also recall the idea that life-histories have been adaptively altered by lengthening out one chapter and telescoping another.

Another saving clause concerns specificity, the individuality and uniqueness of every well-defined type. Increased precision of embryological work has shown that from very early stages in ontogeny an organism is itself and no other. An expert can distinguish an embryo chick a few days old from an embryo duck, before either of them shows any avian characters. There is only a technical difficulty in the way of distinguishing even the cells of an embryo mouse from those of an embryo rabbit, or those of an onion from those of a lily: the number of chromosomes is different. But a recognition of specificity from first to last is not inconsistent with admitting a significant correspondence between steps in individual development and steps in racial evolution. A tadpole is from the first in several ways an Amphibian and not a Fish, and yet in its two-chambered heart and branchial circulation it is for a time distinctively piscine.

One reason why the ontogenetic recapitulation of phylogeny must be general, not precise, is that the successive gains made in the course of racial evolution are not superposed one upon another, but must be severally incorporated into the organisation and unified with it. The additions from millennium to millennium are not like new wings added to a house, for the tenements which we call individuals are continually dissolved, and there is re-unification at the start of each new life. We must remember too that antique characters gradually disappear, thus ancestral birds had teeth, but no embryo bird shows any trace of them. These saving-clauses are of importance, but the broad fact remains that the organism's inheritance, garnered for ages, does in many cases express itself in a step-to-step development, from the general to the special, which is in some measure a recapitulation of stages in what is believed to have been the racial evolution. Some illustrations must be given.

On each side of the neck of the embryo reptile, bird, and mammal there are branchial pouches or gill-clefts which correspond to those which have a respiratory function in amphibians and fishes, and may or do persist throughout life. In reptiles, birds, and mammals these pouches are on the whole transient, like fleeting reminiscences. The first seems to persist as the Eustachian tube from the auditory passage to the back of the mouth, and the thymus gland is connected with another; but the rest pass away without persistent result. They are echoes of the past. In embryos of the chick and of some reptiles, dwindling and transient traces of *gills* in connection with the gill-clefts have been recently discovered (Boyden, 1918).

Similarly, the embryos of higher Vertebrates show for a time a notochord,—a primitive skeletal axis derived from the roof of the embryonic gut, and thus of endodermic origin. It persists throughout life in lancelets and lampreys, serving as the dorsal axis of the animal, as the forerunner of the backbone which, from fishes onwards, develops from the mesodermic sheath of the notochord. The notochord does not become the backbone, though perhaps serving as a sort of tissue-scaffolding for it, and every stage of the replacement of the notochord by its substitute the backbone is seen in fishes. Yet on to man himself the notochord continues to appear in development, a veritable antique; it has its short day and passes, leaving but an unimportant trace behind.

In the establishment of the brain, the skull, the heart, the kidneys, and other important structures in higher animals, the foundations are laid down on old-fashioned lines, not directly suggestive of what is to follow. In the individual organogenesis there is often a recapitulation of historical stages. The development of many an organ appears to the observer to be circuitous, as if the old paths had to some extent to be retrod, and yet the progress of a hundred thousand years may be condensed into one day.

Another aspect of the same fact is that the developing embryos of, say, bird and reptile are for some days very much alike, moving on parallel lines along the great highway of Amniote development; but, sooner or later, about the sixth day in the case of the chick, their paths diverge and become distinctively avian and saurian. Thus does the past live again in the present with compelling force. How are we to think of it?

Ontogeny is the making explicit of the germinal organisation, which is what it is because of phylogeny. The way in which an embryo moves towards a goal as if it had its future consciously in view is due to the fact that it is constitutionally determined by the past, which lives on in the present in a manner peculiar to and characteristic of living creatures. The ages that have gone have bent the bow in the plane along which the arrow of the individual flies. But ontogeny must not be thought of as the uncoiling of a wound-up spring, or as the unpacking of a marvellous treasure-box, or as a series of metabolisms which start one another in succession and enter into increasingly complex inter-relations; ontogeny is a function of the individuality which is somehow condensed within the germ-cell. Perhaps it is not, after all, very different from behaviour! The fundamental fact which we are so far from understanding is that the fertilised ovum is at once the repository of ages of organic inventions and a unified individuality in the one-cell stage of its becoming.

If we adhere to the conclusion that evolution has been a series of discoveries or inventions of the genuinely new, the further question is how the gains have become enregistered in the germinal organisation, which must be thought of as becoming increasingly complex. There are two ways in which this enregistering may be thought of. (1) On the one hand it is *conceivable* that the individual acquirements and experiences of the fully developed individual may in some definite way affect the germinal organisation, and thus the progeny. In this way Lamarckians have thought of the germ-cells as being continually enriched by the gains of the individual organism, or reduced by its losses, and that in a quite definite and representative manner. There are very few known facts which lend support to this view, but it seems premature to foreclose the question by any dogmatic denial of the possibility that individually acquired modifications can leave representative imprints on the organisation, or, as some would say, on the unconscious memory of the germ-cells. It is possible that an increase of knowledge will show us that there is some hidden truth in the Lamarckian position; but the facts do not point that way at present. Deserving of consideration here are the remarkable facts of cellular habit or momentum in metabolism, expounded notably by Prof. J. G. Adami (1918, p. 55 and p. 166). Professor Adami calls attention to facts like the following. Once the cells of the body of a rabbit have got accustomed to producing a counteractive or anti-toxin to ricin (a poison from the castor-oil plant), they may go on producing this antiricin for weeks or months after the original stimulus. There is an organic momentum. In the horse a single toxin unit of tetanus can lead in the process of immunisation to the production of 1,000,000 anti-toxin units. A cold in the head may continue for weeks after the causative agent has disappeared, and thorough sterilisation of the nose has been effected. The cells form a habit, it may be an entirely new habit, and it lasts, "an acquired cell variation becoming, if I may so express it, converted into a cell-heredity". But the difficulty is to pass from such cases to the generations of multicellular animals.

(2) The known facts point to the conclusion that the organic materials of progress are supplied from within, from the fountain of change that there is in the germ-cell. If the metaphor be permissible, and we cannot get beyond metaphors yet, the germ-cell is the blind artist whose many inventions are expressed, embodied, and exercised in the de-

veloped organism, the seeing artist who, beholding the work of the germ-cell, either pronounces it, in the light of the success which it brings, to be good, or else, when it spells ruin, curses it effectively by sinking with it into extinction. There is no difficulty in understanding how a germinal mutation, having arisen, comes to stay. That is provided for in the continuity of the germ-plasm. It is probably, then, by the entailment of the results of intrinsic germinal experiments, and not by the imprinting of the results of individual experiences, that the steps made in phylogeny become registered in the germ-cells, and thus made expressible in the ontogeny for long ages to come.

§ 5. *Nature and Nurture.*

Development is always the result of an interaction between inherited nature (the germinal organisation and activity), and appropriate nurture (air, moisture, space, warmth, food, light, exercise, education, and much else). The two are complementary. Though the direction of development is mainly intrinsic, the degree of expression which the inheritance attains is conditioned by nurture. Theoretically, the point is of interest that there is what may be called an *external heritage* in relation to which the *natural inheritance* must develop. For we are ever apt to isolate too much, forgetting that the actuality is an association of organisms in a definite region. It is of obvious practical importance that the best possible nurture be secured. Otherwise promising variations may remain like sleeping buds, an inherited talent may remain hidden in a napkin in the ground. Hereditary characters are like seeds requiring soil and sunshine and rain. Negatively too it is always possible that alterations of nurture may prevent the actualism of inherited predispositions of a deteriorative sort. In Man's case nurture is very modifiable and largely under control; much is made that is not born, and it rests with Man to determine whether it be ameliorative or the reverse. But it must never be forgotten that the direct effect seems to be restricted to the individual.

§ 6. *The Other Side of Heredity.*

The past lives on in the present, that is what is meant by heredity. There is an inexorableness in the persistence, the so-called transmission, of all sorts of inborn peculiarities, except sterility of course, not only to the third and fourth generation, but far further. Sometimes it is a trivial feature like a shock of white hair; sometimes it is a deadly vice of blood; sometimes it is all bodily, leaving the spirit unblemished, as in certain cripples; sometimes it is a blot on the brain that affects the character, now in this way and again in that, but always perniciously. There is no gainsaying the fatalistic impression that the study of heredity forces upon us, and since heredity is the relation of organic or genetic continuity between successive generations, there can be no other side to it. But there is another side to the fatalism.

(1) There is a growing solidarity among men and women of good-will; there is a wider recognition of the social or racial aspect of parentage; there is an increasing control of life. So that, while words are easy and actual doing is difficult, it is not speaking unadvisedly with our lips to say, that the reappearance of an evil past is not inevitable in the future: it may be blocked in the present. The transmission of defects and weaknesses of a misery-bringing, race-weakening sort can be in some measure checked. A man,

who is captain of his soul, need not submit to the lien that ancestry has over him. Brave words, of course; but history is full of brave deeds. One does not wish to say much about the way in which—by a survival of Nature's régime in the Kingdom of Man—rotten stocks come of themselves to an end; for the tragedy is that they often taint sound stocks by the way.

(2) Moreover, it is ungrateful to forget that the hereditary relation, which depresses us when we lose perspective, secures the entailment of all manner of wholesome human qualities. The true inwardness of heredity is a holding fast of that which is good.

(3) For characters that blend, if the occurrence of blending characters be granted, it may remain true what Galton stated in his Law of Filial Regression,—that there is a regular regression or deviation which brings the offspring of extraordinary parents in a *definite* ratio nearer the average of the stock. This succession-tax is even-handed; the offspring of under-average parents come nearer the mean just as do those of extraordinarily gifted parents.

(4) The hereditary relation is such that it admits of variability, for the temptation to make a quite misleading antithesis between heredity and variation should be avoided. There is a strong specific inertia—the first law of motion, as it were; but there is a copious fountain of change—the second law, as it were. Phrase it as we may, there is something like creativeness, which is always supplying the new raw material of progress. Unless we have quite misunderstood evolution, it implies an emergence of novelties. It is like original thinking.

(5) The quality of the nurture, largely in our own hands, determines the degree to which the buds of good qualities in

our inheritance may be made to unfold, and the buds of bad qualities may be kept more or less dormant.

(6) There is an undeniable moulding power in changes of function and environment, and though the resulting modifications of our plastic organism do not seem to be genetically persistent, *i.e.,* transmissible as such or in any representative degree, they can be re-impressed, if desirable, on each successive generation. This is part of the biology of education.

(7) Lastly, it must be recognised that in our *social heritage,* which is as supreme as our *natural inheritance* is fundamental, there are ever-widening opportunities for transcending the trammels of protoplasm. Wherefore, *Sursum corda:* Let us lift up our hearts.

Mr. Bernard Shaw speaks of "the unbreathable atmosphere of fatalism which is the characteristic blight of Darwinism". We have sought to show that as regards heredity there is air to breathe. It appears to us, moreover, that the fatalists assume a knowledge which they do not possess. A human inheritance is a very wonderful thing; it is very difficult to tell how much or how little a man has got. The son is told that he is handicapped by his father's defects, but it is quite possible that the father's innate defects were fewer and his excellences greater than ever transpired. For the fullness or sparseness of nurture determines the degree of expression which the inheritance attains in development. Of course there are limits. "He that will to Cupar maun to Cupar." "Though thou shalt bray a fool in a mortar, yet will not his folly depart from him." Our possibilities are hereditarily pre-determined, but can this be said of our actual personalities? The higher the organism the greater its unpredictability within certain limits, the greater the power of the higher nature to modify what has undergone automatisation or enregistration, the greater the capacity of selecting and altering the environment. We do not know all the evil that is in our inheritance, therefore we should not take too many risky chances. We do not know all the good that is in our inheritance, therefore we should give it every chance. Biology and history, as well as our conscience, give the lie to the mechanistic fatalism which asserts that we have not, in any measure, freedom of self-development.

§ 7. *Heredity and Personality.*

The greatest advance in the modern study of heredity has been the disclosure of unit-characters or Mendelian characters. It is certain that there are numerous hereditary characters which behave in a distinctive and independent way in inheritance, being distributed as indivisible entities according to a definite scheme. They are clear-cut, either there or not there; they do not blend or intergrade; and they are infallibly present in a certain proportion of the offspring. They seem to be represented in the germ-cells by definite determinants, factors, or genes, the nature of which is unknown. Some have likened them to ferments; others to differences in the ultra-microscopic architecture. It is quite likely that several factors may be concerned in one character, or that one factor may influence more than one character. The gist of the Mendelian discovery is, in Pearl's words, this: "Hereditary differences behave, in the main, as discrete units, which are shuffled about and re-distributed to individuals in the course of the hereditary process, to a considerable extent independently of each other; and in typical cases this re-distribution follows the simplest of statistical laws of dispersal, the point binomial." In illustration of characters that exhibit Mendelian inheritance, the following may be cited, the dominant condition which prevails over its alternative in the first cross-bred generation being named first in each case:—Hornlessness and the presence of horns in cattle, normal hair and long 'Angora' hair in rabbits and guinea-pigs, kinky hair and straight hair in man, crest and no crest in poultry, extra toes in poultry and the normal number four, bandless shell in wood-snail and banded shell; yellow cotyledons in peas and green ones, round seeds in peas and the wrinkled form, absence of awn in wheat and its presence, susceptibility to rust in wheat and immunity to this disease, two-rowed ears of barley and six-rowed ears, markedly dentate margin in nettle leaves and slightly toothed margin. Why one character should be dominant and its alternative recessive we do not know. It is often supposed that a dominant character implies something *plus,* the presence of a definite 'factor'; while the corresponding recessive character implies the absence of that 'factor'. But it is difficult to hold to this consistently.

The modern study of heredity suggests that our personality is made up of many strands which go back into antiquity and which have a unique combination for each individual. The strands are ancient, but the individual, as Jennings (1911) says, "is a new knot". And it seems an important fact that a good deal is known in regard to "the intimate material processes of the interweaving". There is a fresh unification at the beginning of each individual life,—a fresh unification that implies some measure of unpredictability and freedom from the past.

The strands of each individual knot diverge before and behind us. "Those in my knot have come from a hundred others, and may later untie in a hundred still diverse. Of my characteristics I may say, like Iago of his purse, " 'twas mine, 'tis his, and has been slave to thousands". . . . " Our characteristics exist elsewhere in humanity and will continue to exist after that particular knot which forms the present self has been untied" (Jennings, 1911, p. 906).

There is a certain organic immortality which is the lot of all, our strands live on. " It holds as well and in the same sense for him who leaves no children of his own as for the parent." " Each of us is but a knot in a continuous web of strands that have, in other combinations, built up many persons, and will, in still new combinations, build up many persons. Thus as we have before taken part in the development of brute and of man, we may hope to take part in the development of superman" (Jennings, p. 910).

It has been said that to find any enlightenment in the persistence of strands of personality in collateral lineages shows a very tawdry conception of what personality means and a very limited appreciation of the sanctities of human relationships. But this criticism is not quite fair: the biologist whom we quoted and with whom we agree was simply making a biologist's contribution to one of the riddles of existence—the apparent wastefulness of fine flowers that bear no seed. It is very unlikely that the same flowers will ever appear again; the really fine individuality is unique. But it is not unlikely that approximations to the same pattern will recur. There is a conservatism in evolution, which retains qualities on collateral lines even when a particular lineage comes to an end. Mongrelising makes for mediocrity, but eugenic marriages make for masterpieces. One can hardly reproach the order of Nature for cases where remediable social conditions have prevented fine personalities from the venture of parenthood. The deliberate or coerced celibacy of fine types may have implied in some cases an enrichment of the social heritage, but it is very unsound biologically.

In regard to questions with a wider horizon than racial persistence the biologist must—as biologist—remain silent, but it is not unscientific to plead for keeping doors open till they must be shut. The personality of a genius—whether intellectual, artistic, or moral—is an amazing fact, perhaps further beyond the individuality of a dog than that is beyond the unity of an amœba. It is not the general body of the man that is distinctive, but the greatly increased complexity of the nervous system and the correlated new liberty and integration of thinking and feeling and willing. And this personality is still in process of evolution. Who shall fix its limits?

When, after thousands of years of discussion, all remains dark except in the light of Christianity, why should we continue the unending quest? But it is unlikely that man will ever cease from such adventuring, and it is not to be desired as long as the quest does not interfere with the discharge of his daily duties. As Simmias said in the *Phædo,* shortly before Socrates was to die: "I will tell you my difficulty and Cebes will tell you his. I feel myself (and I daresay that you have the same feeling) how hard or rather impossible is the attainment of any certainty about questions such as these in the present life. And yet I should deem him a coward who did not prove what is said about them to the uttermost, or whose heart failed him before he had examined them on every side. For he should persevere until he has achieved one of two things: either he should discover, or be taught the truth about them; or, if this be impossible I would have him take the best and most irrefragable of human theories, and let this be the raft upon which he sails through life —not without risk, as I admit, if he cannot find some word of God which will more surely and safely carry him."

SUMMARY.

Heredity, the genetic relation between ancestors and descendants, between the race and the individual, has to be considered as a condition of racial evolution and as a factor in determining the personal life.

Heredity is the relation of organic continuity between successive generations, securing the persistence of resemblance between offspring and their parents, between progeny and their ancestors, and is sustained by the continuance of a specific dynamic organisation of which the germ-cells are usually the vehicle. The natural inheritance includes all that the organism is or has to start with in virtue of its hereditary relation, and is to be distinguished from extra-organismal legacies, such as Man's social heritage; from the results of ante-natal influence as in most mammals and flowering plants; and from exogenous modifications directly due to peculiarities in 'nurture'. Nurture includes all manner of extrinsic influences,—environmental, nutritional, and functional. Development is the realisation of the inheritance in appropriate nurture.

Heredity is not so much a factor in, as a condition of evolution. It involves arrangements which secure the persistence of a specific dynamic organisation—holding fast that which is good. This is effected by the continuity of the germ-plasm. Nevertheless it admits of the emergence and of the entailment of the new. It serves or tends to prevent the transmission as such of individual somatic modifications either for good or ill. The question arises in what way the personal life counts in evolution.

Although there is not at present any convincing evidence of the transmission of individual modifications as such or in any representative degree, it should be noted that some may serve as variational stimuli; that some may serve as adaptive screens saving the individual until germinal variations in the same direction may emerge and establish themselves; and that it is in the personal life, often

of continuous experimenting, that the germinal variations are tested and sifted.

The conception of the organism as a historic being is well illustrated by the facts of heredity and development. There is the inertia of the great mass of the inheritance, much of which is of very ancient origin. There is a striking persistence of vestigial structures and even habits. There is remarkable staying power in unit characters. There is an indubitable recapitulation of phylogeny in ontogeny, especially in organogenesis. The enregistering of past gains is probably to be thought of in the light of the continuity of the germ-plasm, for it seems that organic progress emerges from within and is not impressed from without.

The individual organism is the outcome of a hereditary nature developing in an appropriate nurture. The direction of development is mainly intrinsic, but the degree of expression attained bears some relation to the extrinsic systematisation, what may be called the external heritage. In Man's case in particular, where the nurture is very subtle and very plastic, much may be made that is not born.

A study of the facts of heredity engenders a fatalistic impression: the hand of the past has such a heavy grip. But "the other side of heredity" must be considered,—the persistence of the stable, the continual emergence of the new, the influence of nurture on the individual, and the dominance of the social heritage. It is important to bear in mind that each organism is in some degree a new individuality with some measure of indeterminateness, and made as well as born.

The modern study of heredity forcibly suggests that the personality is a unique combination of many strands which go back into antiquity. The strands are ancient but, as Jennings puts it, each knot is new. It is tied afresh at the beginning of each new life, and this implies some measure of uniqueness and freedom in the self. Our characteristic strands do in some measure exist in other combinations elsewhere, and may last on, unfortunately as well as fortunately, when our particular knot is untied.

LECTURE XVI.

THE EVOLUTION OF MIND AND MIND IN EVOLUTION.

LECTURE XVI.

THE EVOLUTION OF MIND AND MIND IN EVOLUTION.

§ 1. *Of the Fact of the Evolution of Behaviour There Is No Doubt.*

In a typical human life, thinking and feeling and willing bulk largely, and we naturally inquire into the historical setting of these capacities. We cannot make the mental states of animals the object of direct observation; on the other hand, we cannot believe that mental states began with Man. So we seek for indirect evidence that animals share them. Can we discern stages in mental evolution? And this raises another question: In human evolution the practical importance of mind is certain; has it also counted in the evolution of organisms?

It should be possible to discuss these questions in a scientific way without going into the metaphysical question whether the stuff out of which the world is built can be thought of as independent of mind, and without discussing the difficult question of the relation of mind to body, if it be rightly called a relation. It goes without saying that we cannot derive mind from anything else of a different kind; if we seem to do so we are deceiving ourselves with verbal jugglery. It may also be said at the outset that if the genetic view we adopt here results in suggesting that animal behaviour is easy to understand or is a commonplace affair, then it is being wrongly stated. Whatever view we take as to the nature of mind and its relation to bodily activity, it is a fact that as we follow the main line of animal evolution, behaviour becomes more masterly, more plastic, more like our own. As regards behaviour the slipper-animalcule is surpassed by the earthworm, the worm by the blackbird, and the bird by the cat. There is increasing freedom, subtlety, and resourcefulness of behaviour. Many will admit this at once, who will not take the further step of supposing that the progressive evolution of behaviour is associated with a clarifying and strengthening of what, by analogy with ourselves, we may call the stream of inner life— the flow of feeling, will, and thought. We suppose that there is a rill of inner life growing in volume until it becomes a stream, because as we pass from lower to higher animals there is more and more behaviour that we cannot fully describe in purely physiological terms. But before we think tentatively of the stages in the evolution of behaviour, we must give heed to some preliminary considerations.

§ 2. *Difficulty of Understanding the Process.*

First, we must try to avoid any facile reading of the man into the beast. In ourselves we know that some stimulus often sets agoing a vigorous internal activity of thought-processes, involving an experimenting with imagery and playing with centrally aroused sensations. This goes on in our brain and it brings fatigue. It may be associated with movements in larynx and tongue, with speaking to ourselves, and with changes in eyes and brow and heart; but there is not at the time anything to show for it in our explicit behaviour, and our neighbour offers us a penny for our thoughts. Yet our future action—in the case of a genius, the history of the world—may be modified by this hour of hard thinking. Is there that sort of inner life of the mind-body in animals? We must not expect too much. Not only is our nervous system a much more differentiated and integrated nervous system than that of even the highest animals, but we have language and we have developed the possibilities it affords of inter-subjective communion. A few animals have a limited vocabulary, but no animals have more than the primordia of language, so we must not suppose that the mental furnishings of animals are like our own. Some experts have warned naturalists that the search for reasoning, imagery, and the like among animals must forever remain futile. On the other hand, we should remember that in our own case there is much in mind besides those inferences which we are accustomed to regard as distinctive of intelligence. There is a continuous flow of mingled sensations, perceptions, ideas, feelings, desires, and volitions,—a stream sometimes clear and peaceful, sometimes muddy and turbulent. It is probable that among the lower animals, the flow does not show much in the way of perceptions and ideas, still less in the way of experiments with these. We know that in our own individual development the earlier stages are largely pre-intellectual, mainly emotional. It is extremely improbable that the starfish laboriously disarming the sea-urchin has made any inference on the subject, for its nervous system has no ganglia; but it is difficult to make sense of the operation without crediting the creature with conation, with something of the nature of endeavour, not necessarily with full antecedent awareness, but with a determination of action in relation to the result that will accrue.

Another great difficulty lies in the fact that at stage after stage, as we have seen, there is a tendency to organisation or automatisation of capacities for behaviour, and if we attend too exclusively to these we are apt to get the impression that the naturalist's suggestion of mind is a mere courtesy to the psychologist. But it is necessary to look into the less conspicuous deviations from routine which sometimes show the hand of mind on the reins, and to inquire into the stages of initiative and testing which may have preceded the automatisation.

Perhaps the biggest difficulty of all is to think of germinal variations supplying the appropriate materials for the evolution of complicated instinctive behaviour or for capacities of perceptual inference. Nowhere does the problem of the *origin* as distinguished from the *survival* of fit variations appear so baffling as here.

§ 3. *Provisional Sketch of the Evolution of Behaviour.*

What, then, shall we say of the Evolution of Behaviour?

(*a*) A starting-point may be found in the tentative movements of simple creatures, swimming about in the pond, called hither and thither by slight differences in temperature, oxygenation, and the like, or, if there is no particular stimulus, moving in straight lines, or curves, or spirals—expending their energy, expressing themselves in modes of locomotion which are often characteristic, yet every now and then striking the note of tentative endeavour. There is an occasional new departure, some experiment, a hint of the bent bow. As Professor Jennings has graphically described, the amœba hunts another amœba, captures it, loses it, recaptures it, loses it. Much importance must be attached to simple searchings and probings. As the late Mr. Darbishire put it: "If Necessity was the mother of Invention, Curiosity was almost certainly its father."

(*b*) At an early stage there must have been established a number of particular answers to stimuli, which in the case of Unicellulars may be called organic reactions, keeping the word reflexes for creatures with a nervous system. A good illustration is the answer-back so familiar in the case of the slipper-animalcule, Paramecium. To every hurtful stimulation it gives the same answer:—it reverses its cilia, it retreats, it twists a little on its axis, it feels its way, and goes full steam ahead—often in this way avoiding the obnoxious stimulus. The capacity of exhibiting this uniform reaction is organised or enregistered in the creature; and these ingrained capacities increase in number.

(*c*) The next step is the 'trial and error' or perseverance procedure. One reaction is tried after another, till, it may be, one of the movements relieves the creature from stimulation. The Stentor reacts in four different ways to the microscopic dust which the experimenter showers on it; three answers are ineffective, the fourth saves the situation. There is a persisting state of the organism which *varies* the answers, there is probably a simple expression of conation or endeavour.

(*d*) The main line is continued in such behaviour as is illustrated by multicellular ganglionless animals like starfishes. There is persistent co-ordination of acts towards a definite result. There is sensori-motor experimentation. Our picture here is that of the brainless starfish persistently disarming the brainless sea-urchin, wrenching off the pedicellariæ from area after area. This is purposive behaviour, but the purposiveness has not reached a perceptual level. Consciousness is at work, and its "precise function in sensori-motor action is to grasp the unique combination of stimuli, each of which having its special reaction modified by the concomitant reactions, there follows a response appropriate to the unique situation as a whole" (Hobhouse, *Mind in Evolution,* 1915, p. 62).

(*e*) With the establishment of a nervous system there was opened up the possibility of a new kind of hereditary automatisation or organisation,—that of reflex actions and tropisms. The former are usually movements of parts of the animal, the latter movements of the whole creature. A reflex action is the predetermined result of the activation of an inborn structural arrangement of receptor, conductor, and effector, which gives a uniform response to a given stimulus. It may be very perfect from the first, or it may improve by practice, or it may result from individual habituation: but typically it is an outcome of pre-established hereditary organisation, definite linkages of sensory neurons, associative neurons, motor neurons, and muscular elements. In effect reflex actions seem purposive, but in process they are organisational. If there was originally an operative purposiveness, it has receded into pre-formed structure.

Our pictures are of the sea-anemone closing its tentacles on a victim, of the nestling opening its mouth at the touch of food in its mother's beak, of the starfish surrendering an arm in the spasms of capture, of the young mammal sucking whatever is put into its mouth. Antecedent to reflexes there is more or less random flow of activity which is now and then definitised in experiment and endeavour. Reflexes imply the establishment of definite channels for the flow.

Tropisms are more or less obligatory movements of the whole organism, or of a large part of it, which automatically make towards securing physiological equilibrium in reference to particular stimuli. Thus an organism moves towards or away from light and heat, electric currents and diffusing chemical reagents, water currents, and the earth and so on. It must not be said that heliotropic animals desire the light or dislike the darkness; the tropisms are more or less forced movements which work automatically like a gyroscope.

Our evolutionary theory is that reflexes and tropisms are economical automatisations, enregistrations, or organisations of capacities which are continually being called into action in the ordinary life of the creature. They require neither thought nor endeavour; they are ingrained and almost as much part of the constitution as, say, breathing movements. Their survival value is (1) that they admit of the rapid automatic execution of life-preservative or species-preservative movements (an automatism for which in unusual conditions there may be a heavy tax to pay); and (2) that they leave the organism more free to use, if it can, the second string of purposive endeavour.

(*f*) The main line continues in a kind of behaviour which shows evidence of 'learning', of utilising previous experience to compass an end which is not necessarily immediate. The note of inference is *beginning* to be sounded. There is experimentation and correlation at a higher level than that of the starfish. It is the dawn of intelligence, and may be illustrated by cases like the following. A young octopus trying to capture a hermit-crab is stung by the sea-anemone which is the crustacean's partner. It avoids further encounters. Old octopuses, however, learn to extract the hermit-crab without touching the sea-anemone. Prof. Lloyd Morgan calls this profiting by experience through the exercise of intelligence. Dahl relates that when a spider is given a fly that has been steeped in turpentine, it will not for a time dart at another fly of that species. This is like simple learning.

(*g*) The improvement of the brain opened up a new possibility in the way of hereditary organisation—that of instinctive behaviour. In virtue of inborn nervous predispositions the animal seems to be from the first aware of the significance of certain stimuli and configurations, and obeys an impulsion to a definite routine which is singularly effective, though more or less independent of practice. Pure instinctive behaviour is well illustrated by ants, bees, and wasps; but there and elsewhere it may be mingled with experimental, including intelligent, behaviour. Of instinctive behaviour very perfect in its first performance many pictures rise in the mind:—the chick neatly removing the top of the imprisoning egg-shell, the month-old kitten exhibiting without imitation "almost a complete repertoire of movements used by the adult cat in catching and killing mice", the young guinea-pig nibbling at a carrot at the end of the first day after birth. In illustration of instinctive activities that improve or change under various influences we may recall the pecking of chicks and the singing of some birds. Of the serial succession of steps in instinctive behaviour there is no better illustration than the way in which the Yucca moth on its first flight visits and pollinates the Yucca flowers and lays eggs in the ovary.

(*h*) The next level is that of intelligent behaviour, which is characteristic of the higher reaches of the big-brained line of evolution. It implies trial and error experimentation on subtler lines and more definite profiting by experience. Psychologists interpret it as implying 'perceptual inference', some working with ideas. It is reflective and inferential, as contrasted with instinctive and intuitive.

When the Greek eagle lets a tortoise fall from a height on the rocks below so that its strong carapace is broken, when beavers cut a canal right through an island in a big river—a task not practically justified till completed,—when a collie dog at the bidding of a few sounds and signs accomplishes a really difficult thing in the way of sheep-driving, it is probable that we have to do with intelligent behaviour.

We have seen that, at various lower levels of behaviour, the perfecting rôle of practice is recognisable, and this is the case also at the level of intelligence. We are familiar with the individual habituation of exercises which originally required attentive selection and detailed control. Certain structural changes in the nervous system come about as the result of frequent performance, and what was at first laboured becomes very automatic—or so facilitated up to a certain point that the mind is free to attend to finishing touches. It is not known that the results of individual habituation can be entailed in a representative way on the offspring.

(*i*) The climax is the rational conduct occasionally exhibited by Man. We cannot describe such conduct without using general terms; it involves experimenting with ideas, conceptual as distinguished from perceptual inference; it is controlled with reference to an ideal or conceived purpose. Man has his reflexes and a little instinctive behaviour; most of his activity is either intelligent, or was originally intelligent, but has become habitual; the point is that, if occasion arise, Man may instantaneously pass from a lower level to that of rational conduct.

When we look back over the vaguely discerned succession of modes of behaviour, we detect what may be called the tactics of the evolutionary advance. At level after level, there has been an organisation or automatisation or enregistration of behaviour so that an organism can do things effectively without having to think about it. The answer comes pat, and there is an economy of time and life. In reflex actions, tropisms, and instinctive behaviour we see the activation of capacities which have become part of the hereditary constitution. The great result has been that the organism, freed from having to attend to and control these organised activities, has been able to push on to finer issues. As individuals we are aware of this result being attained by habituation, but there is little warrant for supposing that the successive organisations we have referred to have arisen by the entailment of the results of often repeated performance. We say this because we do not know how it could be arranged, because we have no evidence of the transmission of intelligent-habitual capacities, because some of the most striking pieces of instinctive behaviour occur only once in a lifetime, and for other reasons.

How, then, could the successive organisations be accomplished? The probable answer is that they are all due to germinal variations in the direction of a complexified nervous system. New departures which have been called, from the psychical side, 'inborn inspirations' prompted changes in behaviour, and these were tested and sifted in the individual lifetime. For a time the germinal variation might be in the direction of differentiating and integrating the brain; for a time there might be a specialisation in the seat of some particular activity; and again there might be variation leading to short-circuits.

We are still at the stage of metaphor in regard to the factors in the evolution of behaviour; but metaphor is less dangerous than false simplicity. Our metaphorical picture is this—the germ-cell just beginning to develop is an implicit organism of great complexity, an individuality in the one-cell phase of its being, a mind-body or body-mind telescoped down. It varies, it makes experiments in internal re-arrangement, in self-expression. It is a blind artist, its sketches are submitted to the criticism of the fully-formed organism, the seeing artist, who will put them in the proper light and bring out what there is in them of value.

If the Amœba has in its small way a mind, an aspect of itself corresponding to our mind, and if the Amœba uses it when it goes a-hunting,—two not unreasonable hypotheses,—then it may be that the germ-cell has also its analogue of mind—a not unreasonable hypothesis, since it develops into a creature with a mind. And this leads us to the hypothesis that the more momentous variations may be inexplicable if we keep only one aspect of the germ-cell in view. And if so, could there be a more relevant opportunity for the mental side showing itself than in variations which lead to new departures in behaviour?

In any case, the hypothesis that hereditary organisation of capacities of behaviour comes about by the entailment of the results of individual practice, experimenting, and learning cannot be readily maintained. On the other hand, while it is difficult to think clearly of the origin of great improvements in behaviour by germinal variation, and of the relative automatisation of them arising in the same way, there is no special difficulty in understanding their persistence on this theory. For variations that arise from within have often great staying power in inheritance.

The Germinal Origin of Improvements in Instinctive Behaviour. We must linger over the difficulty, which many biologists feel acutely, of trying to account for improvements in instinctive behaviour by variations in the germ-cell.

When an organ, such as the proboscis of an elephant, has shown in successive ages a gradual increase and differentiation, as the skulls of fossil Proboscidea seem to indicate, the non-Lamarckian evolutionist supposes that this is due to the selection of variants in the direction of elongation, these variants being the expressions of appropriate changes in germinal organisation. The change in germinal organisation, say a strengthening of certain primary constituents, operates during the active process of proboscis-development, or of proboscis-growth, for it need not begin to exert its influence until long after the foundations have been laid. Thus a long-billed bird need not show much or anything in the way of a long bill until after it is hatched. The general idea is that an improvement of structure comes about as the expression of a germinal variation which asserts itself during the activity of development or growth. It is not necessary to think of it as asserting itself only once, for the highly differentiated structure, such as a snail's horn or a newt's lens, may be regrown if it be lost. The germinal variation includes a residual capacity (localised at the base of the horn or in the tissue near the lens) for reproducing or regenerating what has been lost. The general idea, we repeat, is that a cumulative germinal variation, implying a perfecting of some part of the germinal organisation, expresses itself in the course of generations in a cumulative improvement of a certain routine of developmental or growth activity.

If this be admitted as conceivable, then it is not a great step to pass to the improvement of instinctive activities as the result of progressive germinal variations and, of course, the personal testing of these. For the line between development and the expression of instinctive capacity is hard to draw. Both are actualisations of the implicit, the ingrained, the enregistered. Both are expressions of 'organic memory'. As M. Joussain says (1912, p. 156), "Instinct is a prolongation of the organising work: the effort by which the chick breaks its shell, frees itself from the débris, and begins to walk, is a continuation of the development by which its organs have been built up in the egg." He proceeds to say, though the speculation is not necessary for our point: "If the final stroke of the beak is conscious and voluntary, the work immediately antecedent must likewise be so, and thus backwards. It is, then, by its own effort that the egg is developed into a bird." . . . But this will sound absurd to those who are satisfied with the simplicist formulæ of the mechanical school.

Organic Memory. In his interesting *Esquisse d'une Philosophie de la Nature* (1912), M. Joussain makes much of the conception of organic memory. "The transition from mechanism (tropism?) to instinct and from instinct to intelligence, as likewise from automatism to spontaneity and from spontaneity to freedom, is correlated with the extension of memory. In the animal, the complexity and differentiation of the organism are correlated with the extension of specific memory. . . . The relative independence of the organism in respect to its environment increases with its complexity and differentiation, and consequently with the specific memory. The higher the animal's degree of organisation, the more it is capable of altering its reactions in answer to stimuli from without, the more reserve of energy it has and freedom in using it. The independence of the creature is thus greater in proportion to the extent of its remembrance, and in this sense one may say that memory enfranchises it from the dominion of matter."

It seems to us, however, that there is need for discrimination here between the little-brain type, with its climax in ants and bees, and the big-brain type, with its climax in dog and horse. The enregistration of capacities of effective routine reaches a high degree of perfection in ants and bees, and we may call it racial memory if we please. But while it makes for mastery of the usual, it does not bring any gift of freedom—not even of educability. It is an enregistration of capacities of concatenated reflexes, but certainly not of reflection. It is a memory that kills originality. We agree therefore with those who distinguish the enregistering of instinctive capacity from the enregistering of intelligent capacity, the power of discerning relations, of controlled not reflex behaviour. It is comparable in a way to the experience of many students who remember little of what they have learned, read, or even solved, but who have as their reward a capacity of rapid judgment.

§ 4. *The Efficiency of Mind in Everyday Life.*

There is no use going farther without facing the position of those who maintain that all this discussion is an unnecessary complication of the problem, who believe that to speak of an inner life besides metabolism is only a *façon de parler,* who regard mind at the best as a useless epiphenomenon.

The first respiratory movements of the newborn offspring are commanded by delicately adjusted inborn structural arrangements in the medulla oblongata; these are set into activity by external stimuli or by slight changes in the alkalinity (Hydrogen-ion concentration) of the blood; and these again are due to a slight asphyxia resulting from the withdrawal of the maternal circulation.

So when it comes to sucking, swallowing, digesting, and the like, appropriate stimuli pull the trigger of pre-formed adjustment, and one reflex process evokes another, and so the creature gets on.

We have an inherited set of triggers called ceptors, contact-ceptors, chemical-ceptors, thermal-ceptors, and so on; and these are connected with wires, nerves, or conductors, which pass on the stimulus to the areas of muscular activity. There may be threshold-resistances to be overcome so that undue impetuosity of response is avoided; there are arrangements for the summation of stimuli, for laying down paths so that action-patterns are formed; and all has a phylogenetic reference, that is to say, neuro-muscular pre-arrangements work well to-day because all has been wrought out through the ages in reference to frequently recurrent problems. It is hardly possible to exaggerate the nicety of adaptiveness—the brain is the storage battery, the muscles the seat of motor activity, the liver makes fuel and helps to remove ashes, the thyroid gland effects speed control, the adrenal body has to do with counteracting the accumulation of acid waste-products, and so on through the inter-dependent series of organs which make up the kinetic system of the body. What need is there for mind? Is it more than a name for 'versatility of nervous response'?

In an admirable exposition of *Man as an Adaptive Mechanism,* Professor Crile shows how much the human body is good for without any help from the human mind. It is strange, however, that one of his notable advances in surgery is associated with the recognition of the importance of fear or anticipation before operations, and we cannot agree that fear or anticipation is adequately accounted for in terms of physiology. Another strange thing is that Professor Crile includes among the functions of his adaptive mechanism "the fabrication of thought". One might say that it was not a good thought that Professor Crile's mechanism fabricated when it conceived of the organism as a mechanism; but his position is theoretically impossible—a contradiction in terms.

The apsychic formulation seems unsound practically as well as theoretically. On the theory that mind does not count, we may make much of a horse or a dog, but certainly not most. There is a great deal of sound sense, we think, in the quaint words of one of the old breeders, Gervase Markham (1621): "You shall beginne to handle and instruct your dogge at four months old; . . . make him most loving and familiar with you, taking a delight in your company, also mix with this familiarity a kindly awe and obedience which you shall procure rather by tenderness than by terrefying him, which only maketh him sly." It is wrong "ever to hurry your young dogge, give him time to fix himself and much liberty of movement, handle him firmly but tenderly." (Quoted by Dr. N. C. MacNamara in his *Instinct and Intelligence,* 1915, p. 183.)

There are two fallacies in the doctrine of the uselessness of mind. In the first place, it ignores the fact that the process of organisation (otherwise called automatisation and still more unfortunately mechanisation) has the effect of increasing efficiency at a higher level. It enables the creature to meet novel circumstances, to experiment, to make a purposeful use of its own experience, which is what we call intelligence. Just as in our own life we practise labour-saving, time-saving, worry-saving methodical devices, so as to have our mind more free for its own adventures, so the consummate registration that the organism exhibits is a device for the emancipation of mind.

The second fallacy is the assumption that what now takes place reflexly, tropistically, or instinctively never required mental control. Without accepting the theory that reflexes have been organised by habituation, we may recall such experiences as learning to ride a bicycle, which show how extraordinarily automatic movements may become which originally required all our attention and a good deal of strong will. In cases like playing the violin the original efforts often require a good deal of intelligence, for those learn best who see clearly the relation of means to end.

Of reflexes, Professor Sherrington writes (p. 388): "Perfected during the course of ages, they have during that course attained a stability, a certainty, and an ease of performance beside which the stability and facility of the most ingrained habit acquired during an individual life is presumably small. But theirs is of itself a machine-like fatality. . . . To these ancient invariable reflexes, consciousness, in the ordinary meaning of the term, is not adjunct. The subject as an active agent does not direct them and cannot introspect them."

But he goes on to show that, in higher animals especially, reflexes are under some control. We know this in connection with coughing, eye-closing, and smiling. Some people can slow down their heart and suppress the pharyngeal reflex of swallowing. "Certain it is," he continues (p. 390), "that if we study the process by which in ourselves this control over reflex action is acquired by an individual, psychical factors loom large, and more is known of them than of the purely physiological *modus operandi* involved in the attainment of the control."

"My mind to me a kingdom is," and to many men the inner life of contemplation, imagination, æsthetic emotion, hard thinking, and the like, is the real life. In everyday human life we see evidence of the efficiency of mind when a man copes with novel difficulties, when he anticipates a rarely occurring risk, when of set purpose he correlates his acts and those of others towards a distant end, when affective states (such as joy) exert a demonstrable influence on the functions of the body. We should not spend time in making such obvious remarks, were it not for the activity of the hard-headed mechanists, who write, for instance, thus: "So until the opposite can be proved we must accept the proposition that also human intelligence comprises no psychical factor, and that it has arisen phylogenetically through continual transformation and refinement of physico-chemical nerve-processes."

It is interesting to notice the growing tendency to recognise both physiological and psychological factors in the chain of causation of mental and nervous disorders. Thus Dr. Bernard Hart writes (1918, p. 16): "We have, indeed, reached the paradoxical conclusion that, while in many 'mental' disorders mental factors play only a minor part amongst the causes which have produced them, in 'nervous' disorders these mental factors are of fundamental significance. . . . The conviction that in the so-called nervous disorders the predominant part is played by mental causes has been steadily growing during the forty years which have elapsed since the work of Charcot, and has been greatly strengthened by the experience given to us by the war."

§ 5. *The Evolutionary Efficiency of Mind.*

What is true of the everyday human life is true also in history that mind has counted for much, notably in traditional folk-ways and ideals, and in the external registration of ideas in literature and art. The question is whether mind has practically counted in Animal Evolution.

To this question two extreme answers have been given. According to the thoroughgoing mechanistic school what is called mind has not been in any degree a *vera causa* in evolution. Thus one of them, Le Dantec, writes that consciousness is certainly not an acting partner in the firm of life, it is at most a sleeping partner.

According to the thoroughgoing vitalist school, mind is the essential driving force in all evolutionary change. Thus Samuel Butler maintained that it was necessary to have a psychological theory of heredity and a psychological theory of the origin of organic novelties, besides recognising at every turn that the organism is a genuine purposeful agent, striving, endeavouring, trying to make the best of things. Dr. W. MacDougall may be cited as a modern animist who thinks, for instance, that the truest description of even individual development is one which recognises the efficiency of an *anima animans.*

Can we steer between the Scylla of Montaigne's generous anthropomorphism and the Charybdis of Descartes's simplicist automatism? We cannot accept the view that mind is the essential driving force in all evolutionary change, since this depreciates what we may call the physiological driving force inherent in organisms, simply as unified protoplasmic reaction-systems. We quote again what Spinoza said: "No one has yet learned from experience what the body, regarded merely as body, is able to do in accordance with its own natural laws, or what it cannot do." On the other hand, we cannot accept the apsychic view, because it gives a false simplicity to the facts, and because it implies a gap between man and animals which our experience of higher animals and lower men leads us to regard as incredible.

Our theoretical position is that certain pieces of behaviour can be approximately formulated in terms of the organisation and metabolism of the animal as treated of in sound physiology of a non-mechanistic type, but that there are other pieces of behaviour which cannot be approximately formulated without postulating factors like desire, conation, imagery, feeling, correlating, putting two and two together, interpreting perception in light of memory, awareness of the relation of means to end, and, in the most advanced stage, deliberately thinking or experimenting with ideas. We are not supposing that these expressions of mentality are independent of metabolism; we say merely that the concept 'Organism' has to be enriched by that of Body-mind or Mind-body.

Our problem, then, is to indicate the lines along which we may look for indirect evidence that Mind, in the sense defined, has counted in Organic Evolution, in "life's innumerable venturings". The great Russian embryologist von Baer said that "the history of Nature is nothing but the history of the ever-advancing victory of spirit over matter". Was von Baer right or do animals, for instance, play the game all unawares and unbeknown to themselves?

We may refer, to begin with, to the way in which some creatures select their environment. If organisms were agents in producing those novelties which we call variations and mutations, as a bird is an agent in building a nest or a spider in weaving a web, we might say that they were artists of their own fortunes. But the variations and mutations are due to the organism in the germ-cell phase of its being, and, whatever be our surmise, we have no data for speaking of the mentality involved. What we do know, however, is that the full-grown organism sometimes plays these novelties as cards in its game; it puts them to the test of use; it experiments with them; it tries what locks these new keys will fit. It seems to the open-air naturalist indisputable that the organism is an experimental agent.

Prof. James Ward laid emphasis many years ago on what he called subjective or hedonic selection on the part of animals. Without denying the importance of natural selection, he directed attention to organismal selection. Environment selects organisms, in a metaphorical sense; organisms select environments, in a less metaphorical sense. Creatures seek out corners that please them most, that suit them best; and this selective agency on the creature's part has been one of the conditions of that advance from lower to higher forms which has puzzled so many.

"Thus—even if there were no natural selection of variations fortuitously occurring, and even if there were no struggle for subsistence, still—the will to live, the spontaneous restriction of each individual to so much of the common environment as evokes reaction by its hedonic effects (with the increasing adaptation and adjustment that will thus ensue), and, finally, the pursuit of betterment to which satiety urges and novelty prompts,—these conditions, really implying no more than the most rudimentary facts of mind, will account for definite variations to an apparently unlimited extent" (*Naturalism and Agnosticism*, I, 1899, p. 229).

There is little knowledge as yet in regard to variations which arise in response to environmental stimuli, and as to modifications which result from changed environmental influence we do not know that they are transmissible, so that the importance of subjective selection may not be so *direct* as Professor Ward supposes. But its importance may be great if the organism picks out corners in which it can use its individual peculiarities most effectively, where it can give them a chance, where it can test them, where it can gain elbow-room for having more. Needless to say in attributing importance to the animal's selection of environment, we must walk warily. Professor Ward says that " in subjective selection there is nothing metaphorical ", but we have to make sure in each case that there is really selection, in which the organism feels and wills and knows. In a green environment a spider-crab masks itself with green Algæ, but it will do this without guidance from its brain. If when covered with borrowed livery of green it be transferred to an aquarium half green, half red, it always goes to the green half. If its livery be red seaweed, put on in a red environment, it will go to the red half. But we must not say very much about the choice being consciously related to the disguise, for a crab that has lived for a while in a green environment is always positively susceptible to green, and will always go to the green side even with no disguise on.

It is probable that personal agency has operated in cases among big-brained animals where there has been a drastic change of habit and habitat. Thus Alfred Russel Wallace referred with reasonable admiration to the water-ouzels or dippers. These well-known birds are relatives of wrens, with very short wings and tail, and very dense plumage. They frequent, exclusively, mountain streams in the northern hemisphere; they fly under water; they walk along the bed of the torrent; they are continually immersed without getting wet. Doubtless the habit was gradually perfected, but it is difficult to escape the view that the dippers showed more than physiological endeavour in utilising their variations in reference to the extraordinary change of life which they illustrate. To some extent they probably selected the "vacant place" in Nature which they have won. For here "we have a bird, which, in its whole structure, shows a close affinity to the smaller typical perching birds, but which has departed from all its allies in its habits and mode of life, and has secured for itself a place in nature where it has few competitors and few enemies" (*Darwinism,* 1889, p. 117).

There is another promiseful line of inquiry,—to study among animals with complex brains any unusual devices which are not part of the ordinary routine of the creatures' life nor absolutely necessary for the survival of the race. It is desirable to exclude, in the first instance, all devices which fall into these two categories, lest we be misled by extraordinary instinctive capacities, which, at any rate, are not so clever as they look. The cases we are thinking of may be illustrated by the way rooks and gulls lift exposed cockles and mussels in their bills and allow them to fall from a height on the hard shingle so that the shells are broken and the flesh made available. It is very unlikely that the device was thought out; but it is probable that the birds intelligently took advantage of a hint which a chance fall afforded.

A third line of evidence may perhaps be found in persistent endeavour towards a distant goal. There is a kind of vital inertia that admits of physiological explanation. A plant goes on growing up to a certain limit, and this may be for a time accelerative, as in the case of a green leaf, which utilises more and more matter and energy the larger it grows. The almost ceaseless movements of relatively simple creatures, like jellyfishes, or of more complex creatures like water-mites, or of still more complex forms like fishes, may illustrate this organic inertia. Perhaps not very much higher is the way in which a burrowing beetle-larva will eat on and on with little or no interruption under the bark of the tree, until its constitution begins to change and it becomes a pupa just below the surface. The degree of conation (if any) that may be reasonably assumed in such cases, must remain at present a matter of opinion. But organic momentum or perseverance proves inadequate when there is persistent, yet interrupted, co-ordination of activities towards a distant result. The following interesting case is quoted by Professor Hobhouse (*Mind in Evolution,* 2nd Ed., 1915, p. 80).

"A sandhopper is feeding amongst seaweed and a crab approaches behind a clump of weed; which he uses as 'cover'. There was a distance of about eight inches between the two animals, which the crab had to cross without alarming his victim. Presently he left his cover, and, crouching down, crept towards the sandhopper. When he had got about half-way, the sandhopper stopped eating, and turned towards the crab, which immediately disappeared in the sand. Presently the sand rose nearer the sandhopper, the crab reappeared, took a stealthy step or two towards the victim, and then sprang upon him. There are here a succession of acts of diverse character—watching, stealthy creeping, hiding, and pouncing, all brought into operation as the case required." . . . Here is a series of sensori-motor acts adjusted from moment to moment, not to a series of simple sense stimuli, but to the changing phases of a complex situation. Is not this beyond physiologically explicable inertia or momentum?

Those who believe that the only realities are objective physical things and processes (the monistic panhylists) are of course aware of the behaviour of the higher animals, but they regard this as purely objective, leaving consciousness out. Against this view many objections may be urged; Mr. W. P. Montague states four (1912, p. 271). (1) We can be conscious of our behaviour. "But if behaviour is itself consciousness, there seems nothing left in terms of which we can define the consciousness of behaviour." (2) "Behaviour is always a movement or chain of movements in space either of the organism as a whole or of something in the organism, such as neural current. But the square root of minus one of which we are conscious is not a bodily movement, nor is our consciousness of the life of Julius Cæsar." (3) "All that is visible or profitably observable as behaviour relates to movements, with which it is physiologically impossible for consciousness to be identified or even directly correlated. For physiology teaches us that consciousness depends upon, or is immediately and directly bound up with neural currents which are always intra-organic, if not intra-cortical." (4) "Finally, consciousness does at each moment of a train of conscious behaviour have for its contents past incidents of the behaviour that *are* no longer and future incidents that *are* not yet." In short, it seems impossible either to get rid of consciousness,—a strange 'psychophobia', or to define it in terms of any objective process.

What is implied in saying that the mind counts in behaviour? What distinguishes an *abc*-process, in which mind operates, from an *ab*-process, such as a simple reflex action, which may be called purely physiological? The clearest answer that we know to this question has been given by Prof. C. Lloyd Morgan (1915, p. 10). "The *c*-factor is not mere awareness. It is always *pre-awareness.* It is always awareness which, by however little, forestalls the coming event; always in a measure anticipatory; always representative of that the like of which may follow in sensory presentation. It is always this at its very lowest level; and at its highest level it is this developed into definite and distinct prevision of ends, thus rising to the fully teleological status. Furthermore its presence or absence, as criterion of mind, is not only a speculative problem but one of inference based on evidence afforded by observation. When an organism profits by experience, as we say,—when for example a chick avoids nauseous caterpillars after (and only after) seizing their like in its bill,—we may infer pre-awareness of what is, or may be, just coming in further presentation. This is our *c*-factor in an early phase of development; and even at this early stage the study of behaviour may afford evidence from which its presence or absence may be inferred."

"What, then, does such pre-awareness imply? It implies (1) the prior occurrence of direct awareness of like nature; (2) the retention of some change of structure associated with such direct awareness; (3) the revival of awareness in representative fashion; and (4) the time-precedence of this revival to the occurrence of like awareness in sensory presentation. If, for example, a chick has pre-awareness of the taste-meaning of the lady-bird it sees, there must have been prior awareness of live insects as nauseous; the effects of that prior awareness must be structurally retained; the meaning must be functionally revived; and this must 'prevent'—both in the older and in the more modern sense of this word

—the recurrence of the nauseous taste in sensory presentation. It is this prevention which renders pre-awareness effective in the guidance of behaviour."

Now, if this view, so clearly expressed by one of the founders of comparative psychology, be correct, we get two flashes of light on the problem of the evolution of 'mind'. While no suggestion can be offered as to the first emergence of the psychical factor—say the pre-awareness of meaning within a sphere of interest—we may find a pre-condition of it in the physiological capacity of registration and retention which has been recognised as one of the characteristics of organisms. And secondly, in the minute structure of the brain (notably the cerebral cortex) of higher animals there is what may be called an appropriate anatomical basis. That is to say, there is a 'loop-line' system, in which inhibiting or controlling cells intervene between the receptive or sensory centres receiving sense-impressions and the effector or motor centres commanding action. As Prof. Lloyd Morgan tersely puts it, "We are now in a position to characterise our *abc*-process as that of loop-lines whereon pre-awareness, prospective meaning, or prevision of ends, intervenes between the sensory presentation and the response" (1915, p. 12).

Very suggestive of mentality are some of the variations in play-instincts as exhibited by kittens, puppies, kids, lambs, and the like. Mr. Hamerton describes the diversity of games exhibited by his young goats, one succeeding another when a new suggestion was made. A psychological element is surely hinted at in cases which seem to the observer like sham-hunts or sham-fights, but it is not the old-established forms of play that seem to us most significant, for they are instinctive. We see more interest in novelties. Thus Dr.

Levick gives a graphic description of a pastime among Adélie penguins in the Far South. They would board an ice-floe until it could hold no more, and get carried by the tide to the lower end of the rookery, where every bird would suddenly jump off and swim back against the stream to catch a fresh floe and get another ride down.

A digger-wasp coming to its burrow with a paralysed spider has been seen to place its booty in the fork of a plant away from the ants. Another has been seen to grip a small stone and use it to beat down the earth over its burrow. Forel's ants brought from Alegeria, where they have open doors to their nests, began to close them with pellets when they were bothered by visitors of other species. Very suggestive also of awareness are some of the normal changes in instinctive behaviour. Thus some woodpeckers bring their young first seeds, then partly opened cones, then complete cones.

The scientific mind is almost morbidly afraid of being too generous; but common sense recoils from making the world magical. Thus it is well known that instinctive behaviour often changes greatly with the state and situation of the organism, and it is usual to give physiological explanations of the change. We often doubt if these physiological explanations are adequate until we supplement them with Prof. Lloyd Morgan's view that instinct is "organic behaviour suffused with awareness". Speaking of the Noddy Tern, Prof. J. B. Watson writes: "Before the egg is laid the birds are timid and will fly up at the slightest disturbance. After the egg is laid the birds become exceedingly bold. They will fiercely attack the encroachment of any other bird and will even attack the human intruder. A large number of the birds will actually sit on the nest and allow themselves to be removed bodily from it before offering to fly." . . . The egg is kept constantly covered. "They turn it round and round with the beak; they go to the water to wet the breast feathers to keep it moist; they shove one another aside, when the shifts are made, without exposing the egg for any length of time." When we are dealing with a big-brained effective organism like a Tern we cannot help feeling that the description does not lose in scientific accuracy by allowing a modicum of awareness.

Another way in which some degree of intelligence may have evolutionary import is in connection with habit-forming. Many of the higher animals are born with very imperfect capacities, but they eke this out by the rapid acquisition of habits. Given an imperfect pecking-capacity, the adaptation may become perfect by habituation. Now we do not suppose that all habit-forming implies mental processes, but we maintain that some do, namely those which involve an appreciation of the situation. It is said that batting and bowling are hard intellectual exercises, involving a multitude of rapid judgments. So it may be with some vitally important habits of animals; and survival is with the educable.

Some interesting data bearing on our problem may be obtained from a study of what may be called conventions among social animals. Taking penguins again, a case where independent observers confirm one another, we find that the early incubatory task is very arduous, involving in the Adélie penguin a minimum total abstinence from food of about eighteen days and a maximum of twenty-eight. Later on, the two parents relieve one another at frequent intervals, and they have a good deal of what looks like 'fun'. To get more time without leaving the young birds to be killed by skuas or by 'hooligan' cocks (idle bachelors and wicked widowers) the parents "pool their offspring" in groups, which are left in charge of a few conscientious philo-progenitive persons (there is great individuality among the members of the penguinery), who ward off the skuas and do their best to keep the chicks from straying. The holidaying parents bring food at intervals—when their conscience smites them—and they remain loyal to their own *crèches*. If a story like this stood alone we would think that the generous interpretation we have hinted at was mistaken, but there are a great many stories of this sort, so many that the apsychic theory of the laboratory-naturalists begins to appear like a superstition.

Living creatures are often treated too generously, for they are extraordinarily limited in many ways. This is peculiarly true when instinctive capacities are strong. With different individuals of the now extinct Passenger Pigeon, Professor Whitman made the simple experiment of removing the eggs a few inches outside the nest. The bird returning sat down in the nest as if nothing had happened; seemed to feel dimly, however, that something was wrong; she missed something, she knew not what, for she showed no interest in the two eggs lying within reach; after a few minutes she flew away. Of course we must not be too hard on her, for even rational social personalities sometimes behave in a quite extraordinarily stupid way when their routine is disturbed.

But our recognition of the limitedness that often marks the animal must not be allowed to become an obsession, and we venture to think that there is a good deal to be said for the common-sense view which credits the big-brained type, where instincts are not dominant and where educability is well-marked, with the analogues of our perceptual inference, our simpler emotions and affective states, and our desires and volitions.

If birds, for instance, have no genuine joyousness, they make at times such an extraordinarily good imitation of it, that a statement of the apsychic theory gives one a disagreeable impression—that if this be accurate, then we are living in a conjuring show.

> "'Tis the merry nightingale
> That crowds and hurries and precipitates
> With thick fast warble his delicious notes,
> As he were fearful that an April night
> Would be too short for him to utter forth
> His love-chant, and disburthen his full soul
> Of all his music."

Is this good poetry and bad science? Is the joyousness only in "the raptured ear of men", or has the nightingale really a full soul?

The critic says: But if the nightingale, why not also the cricket and other insect-instrumentalists? Perhaps the best answer would be "Why not?"; but we are inclined rather to point out that the bird has a highly developed brain, not on the same line or level as that of higher mammals, but still a fine 'big brain', which may be reasonably credited with the possibility of a stream of 'inner life' fuller than is likely to flow in any representative of the 'little-brain' line of evolution.

The critic again intervenes, pointing out that these nerve-storms of excitement are due to the liberation of internal secretions, and that they may be induced by injections and by dieting. That of course is the physiologist's business, to work out the series of metabolic happenings; but our point is that in the cases which are experimentally open to us, namely ourselves, we know that a physical event,—such as the receiving of good news,—will, we cannot explain how, except on the unity-of-the-organism theory or symbolism, set in motion a series of physico-chemical and vital processes, complex beyond the ken of the wisest.

There is another line of evidence of a particularly interesting kind, that obtainable from the records of trained animals. A dog may exhibit remarkable ability in doing certain things in response to words. Speaking from where he could not be seen in a room in the Johns Hopkins Laboratory, Mr. Dixie Taylor said to his dog Jasper, "Go to the next room and bring me a paper lying on the floor." The dog went and executed the command; it appeared to have an associative memory for about a hundred words. Prof. J. B. Watson, a tough-minded behaviourist, ends his chapter on "The Limits of Training in Animals" by saying "the behaviour laboratories must be prepared to admit that the sympathetic upbringing of animals in the home, where they are thrown into constant contact with human beings, does produce in them a certain complex type of behaviour for which the laboratory concepts, as they now exist, are inadequate to supply explanation".

A terrier was allowed in the dining-room, where it sometimes received a bone from the table. The convention was that the door was at once opened for it when it sought exit with the bone in its mouth. It disdained bread. One evening it heard barking outside. It had, however, on that occasion no bone. It snapped up a piece of bread and made for the door. When it was opened, it dropped the bread and ran out to join its fellows (McCabe, *Evolution of Mind,* p. 222).

Professor Whitman once said that he had studied pigeons for so many years that he got as far inside their heads as it was possible to go without metempsychosis; and it is probable that a reliable appreciation of the depth of animal life may be got by making a sympathetic study of some suitable animal like dog or horse. For there we meet with something approaching our own personality, which leads us on just as our mother's personality did in most momentous ways long ago. The animals also may become aware in new ways of our personality and send out tendrils of intelligence and emotion which are impossible in ordinary circumstances.

Lastly, may we notice once again the risk of concentrating attention on reflexes, tropisms, instincts, predispositions, habituations. If we have read the story aright it is part of the tactics of evolution to increase organisation or enregistration so that freedom may be more worth while. How inaccurate might be a parsimonious account of the intellectual value of the daily routine of a very methodical worker. Only in flashes does the intelligence or the reason gleam out convincingly. We should look out for such flashes in animal life. We see one when a wounded dog, being dressed, checks a bite and turns it into a caress.

Was Hume ironical when he said, "No truth appears to me more evident than that beasts are endowed with thought and reason as well as men. The arguments are in this case so obvious that they never escape the most stupid and ignorant." The fact is that it is peculiarily difficult to find evidences of thinking among animals. We cannot find an objective criterion of intelligence; we have to rely on the treacherous argument from analogy. Yet how are we to establish a contact between our mind and a bird's or to find a common denominator between our behaviour and a hive-bee's? We are faced with the dangers of fanciful anthropomorphism on the one hand and false simplicity on the other. Perhaps we should rest satisfied in the meantime with a general cumulative impression. Certainly we should avoid staking any conclusion on particular cases. We must try to refrain from Lo Here! and Lo There! One of the most beautiful things in the world is the dawning of feeling and thinking in a child; it is like the coming of spring. But how impossible it is to punctuate. Similarly we must hesitate as to the boundary lines in Animal Evolution between behaviour which can be adequately described physiologically and that which requires the use of subjective terms if we are to do it justice. Perhaps it does not matter very much, for the organism as we know it is a unity; never only body, never only mind. Our knowledge is not sufficient yet to allow us to say, except in a few cases, when it is acting more as a body-mind and when more as a mind-body. But what seems important in our interpretation of Animate Nature is the cumulative evidence that in organisms also there is a flow of inner life, though it be but a slender rill as compared with our full stream.

There is something to be said, too, if we believe in continuity of evolution. Enthralled as many weak or oppressed human lives are, there is ample experience of self-determination, and, after all, the most potent force in the world may be a new idea. Now, inclined as we are to emphasise man's apartness, we feel the extreme improbability of the view that in the animal world, with which he is solidary, mind does not count. In plain words, the apsychic view is outrageous.

SUMMARY.

As we follow the main line of animal evolution we see behaviour becoming more complicated and masterly, more like our own. There is evidence of a rill of inner life growing into a stream, *i.e.*, there is much that we cannot fully describe in purely physiological terms, there is an increasing difficulty in describing what we see without using psychological terms. This proposition can be discussed apart from any theory of the mind-body ' relation '. It must be noted that it is very difficult for Man to get mentally near the lower animals, whose mental stream is probably in greater part pre-intellectual, more conative than cognitive.

(*a*) In the evolution of behaviour a starting-point may be found in the restless tentative movements of Unicellular Animalcules, not far removed from internal automatic movements. (*b*) Gradually there is established a capacity for reacting in a uniform way to frequently recurring stimuli. (*c*) The next step is the pursuance of a trial and error method, one reaction being given after another, until, it may be, one relieves the stimulation. (*d*) The main line is represented by such behaviour as an amœba exhibits when on the hunt, and this is continued into the sensori-motor experimentation and co-ordination of acts exhibited by ganglionless animals like starfishes. (*e*) The establishment of a nervous system opened up the possibility of another kind of automatisation,—that of reflex actions and tropisms. (*f*) The main line is continued in experimental behaviour at a higher level, where there is definite evidence of ' learning ', where the creature utilises its own experience to compass an end which is not necessarily immediate. (*g*) The improvement of the brain opened up the possibility of another kind of hereditary organisation—that seen in instinctive behaviour. There is a hereditary awareness of the practical significance of certain configurations and an impulsion to an effective routine which is in some measure independent of practice. Instinctive and experimental (sometimes intelligent) behaviour are often mingled, sometimes the one element predominates, sometimes the other. (*h*) The main line is continued into intelligent behaviour, implying experimentation and perceptual inference. Of this in the individual lifetime there may be habituation. (*i*) The climax is in Man's rational conduct, implying conceptual inference and rational purposefulness.

The general feature of the whole evolution is that organisation or automatisation is effected at stage after stage, so that the organism is able to push on less embarrassed. The general result seems to be a growing emancipation of mentality—growing evidence of a subjective aspect over and above ordinary activities.

According to the extreme mechanistic schools, behaviour is, or will be, thoroughly explicable in physiological terms, *i.e.*, in protoplasmic terms, *i.e.*, in physico-chemical terms. Even Man is but an "adaptive mechanism", we are told by a physiological authority, who enumerates, however, among the functions of the mechanism "the fabrication of thought"—including the concept of "adaptive mechanism". But this view is a contradiction in terms theoretically, and a contradiction of common-sense practically. On the apsychic theory, that mind does not count, we may make much of horse and dog, but certainly not the most. In man's everyday life (apart from contemplation, imagination, æsthetic emotion, hard thinking, and the like), there is familiar evidence of the efficiency of mind in coping with novel difficulties, in anticipating a rarely occurring risk, in the purposeful correlation of acts towards a distant end, in the influence of affective states (such as joy) on the functions of the body, and so on. Of similar efficiency among animals there is presumptive evidence.

The further question is whether mind has practically counted in Animate Evolution. Some have answered that mind is not in any degree a *vera causa* in evolution. Others that mind is the essential driving force in all evolutionary change. But a middle position seems more defensible.

There is a physiological driving force in organisms, and in many cases they are body-minds rather than mind-bodies. But the evolutionary efficiency of mind is seen among animals in the search for suitable environments, in intelligent life-favouring devices, in persistent endeavour towards a distant goal, in training the young, in the conventions of social life, in the impelling influence of emotions, and in many other cases. Cunning has been more of a factor than luck.

LECTURE XVII.

NATURE CROWNED IN MAN.

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§ 1. *Differentiation and Integration as Standards of Progress.* § 2. *The Probable Phylogeny of Man.* § 3. *Man's Solidarity with the Primate Stock.* § 4. *Man's Unique Position.* § 5. *Factors in the Ascent of Man.* § 6. *Human Evolution Contrasted with Animal Evolution.* § 7. *In What Sense May It Be Said that Nature Is Crowned in Man?*

§ 1. *Differentiation and Integration as Standards of Progress.*

The genealogical tree of animals is like a great candelabrum, whose branches arise at different levels, but reach at their terminations to approximately equal heights, if height be estimated by elaborateness of structure and correlation of function. Except as regards brain, some details of cardiac structure, and the absence of an ante-natal symbiosis between offspring and mother, the eagle is almost as highly differentiated and integrated as Man. In skeleton, locomotion, breathing system, and eyesight the eagle excels the man, but it is on a different evolution-tack. Similarly, the bee is on its own line hardly inferior; its sensory, nervous, muscular, and respiratory systems reach a very high level. If organic evolution had stopped with insects it would still have been a succession of achievements that angels might desire to look into. The entomologist watches by the most copious fountain of wonder in the world,—a well of surprises for eye and intellect.

Why, then, is it agreed, by learned and simple alike, that birds and mammals are the highest animals, since it is difficult to show that they excel insects in differentiation and integration,—the plummet and square with which we measure progress? It cannot be that it is simply because they are superficially likest man, for birds are on an entirely different line. The reason is that in birds and mammals there is the fullest expression of what may be called the general trend of evolution, and of what we hold as of supreme value: (1) freedom, individuality, mastery of fate, a power of triumphing over the inorganic, intelligent resourcefulness, and (2) consciousness, possessed joyousness, satisfaction in work and family. So as to Man, scientifically regarded, he is the highest organism because of his all-round excellence of differentiation and integration, and especially because he has far and away the best brains. But on broader grounds Man excels all masterpieces in the realm of organisms because in him there is the fullest expression of what evolution seems to make for, and because he is Nature's only interpreter.

§ 2. *The Probable Phylogeny of Man.*

The story of the Ascent of Man as told us by an expert like Prof. Arthur Keith is very impressive. During the Early Eocene ages, perhaps three million years ago, when grass was beginning to spread like a garment over the earth, there emerged an arboreal race of Mammals, the Primates, differentiated from other orders in digits and teeth, skull and brain. From this stock there diverged in the Eocene, first the New World Monkeys and then the Old World Monkeys, leaving the main line (from our point of view) none the worse. Æons passed and the main stem, feeling its way towards the light, gave off in the Oligocene the branch of small apes (gibbon and siamang) and later the branch of large apes (gorilla, chimpanzee, and orang). This left, towards the end of the Oligocene (others would say in the Miocene), a generalised humanoid stem, perhaps weaker physically by the divergence of the apes, but probably dependent more on wits than strength. According to Professor Sollas's estimates this sifting out of the generalised human stem occurred some two million years ago. Once we have parted company with Archbishop Usher there is no use haggling over a million less or more.

Ages passed, at all events, and from the humanoid stem there diverged first of all Pithecanthropus the erect. It must be confessed that we do not know much about him, whose sparse remnants were found on the banks of the Bengawan near Trinil in Central Java, but we get just a glimpse of a being "human in stature, human in gait, human in all his parts, save his brain". The date was perhaps late Pliocene or early Pleistocene, and there seems little doubt that Pithecanthropus belonged to a collateral humanoid stock, away from the main line.

The same sifting-out process appears to have been repeated time after time. It was in all probability in the Pliocene that there took origin the Neanderthal species, which reached its climax and passed away with apparent suddenness (like aboriginal races to-day) in the Mousterian or middle Palæolithic period. There is no doubt that in middle Pleistocene Age, men of the Neanderthal type, quite distinct from those of to-day, were widely represented in Europe, along with woolly rhinoceros, mammoth cave-bear, ibex, bison, and cave-hyæna. He was a loose-limbed fellow, the Neanderthaler, short in stature and of slouching gait, but a skilful artisan, fashioning beautifully-worked flints with a characteristic (Mousterian) style. He used fire; he furnished his dead with an outfit for a long journey; he had a big brain. But he had great beetling, ape-like eyebrow-ridges and massive jaws, and he showed "simian characters swarming in the details of his structure". Prof. William King, a quiet worker at Queen's College, Galway, protested in 1864 against Huxley's conclusion that the Neanderthal man was merely an extreme variant of the modern type, and proposed to establish a new species, *Homo neanderthalensis;* and this is the view generally accepted to-day. It seems certain that, although the Neanderthaler had many anthropoid features, he was not a low type, that he had his own peculiar adaptations and specialisations, and that he was not ancestral to modern man. Indeed, men of the modern type seem to have been in existence when the Neanderthal man was still living. What may the Neanderthaler have thought of his own species dwindling and another taking its place,—another which he perhaps despised? What if there had been no other?

Again the story repeats itself, and there is a divergence of another branch from the main human stem. We refer to the early Briton of the Sussex Weald—the Piltdown skull, one of the interesting discoveries of the beginning of the twentieth century. There is abundant uncertainty, one must admit, but the Piltdown skull perhaps dates from an early phase of the Pleistocene or from a late phase of the Pliocene epoch, perhaps half a million years ago. Its great interest is its remarkable mixture, *e.g.,* in teeth and jaws, of simian and human characters. The anthropoid characters of the mouth, teeth, and face, the massive and ill-filled skull, the simian characters of the brain and its primitive and pre-human appearance are held by Dr. Arthur Keith to justify

Dr. Smith Woodward's conclusion that the skull requires the establishment of a new genus in the family Hominidæ. If so, it represents another sifting out, another blind alley, another breaking of the mould in which a wonderful creation was cast. For the early Briton of the Sussex Weald was no ancestor of ours.

We must include in our conception of our race the fact of solemn antiquity, and the fact that we had distant relatives who came to nothing although possessed of very high qualities. For one of the interesting conclusions at which Dr. Keith has arrived, after painstaking reconstruction of the data, is that the Piltdown brain was well within the modern human standard of size. And this was at the Pleistocene period or earlier, perhaps half a million years ago. "All the essential features of the brain of modern man are to be seen in the brain cast. There are some which must be regarded as primitive. There can be no doubt that it is built on exactly the same lines as our modern brain."

"Although our knowledge of the human brain is limited —there are large areas to which we can assign no definite function—we may rest assured that a brain which was shaped in a mould so similar to our own was one which responded to the outside world as ours does. Piltdown man saw, heard, felt, thought, and dreamt much as we do still. If the eoliths found in the same bed of gravel were his handiwork, then we can also say he had made a great stride towards that state which has culminated in the inventive civilisation of the modern western world" (Keith, 1915, p. 429). There is something awe-inspiring in the fact of the coming and going of *tentative men*—of Java, Neanderthal, and Piltdown—who had their day and ceased to be, creatures not unlike ourselves, but with more clay in their legs, our predecessors but not our ancestors. Was Emerson thinking of this sort of thing when he wrote:

> "Thrice I have moulded an image,
> And thrice outstretched my hand,
> Made one of day, and one of night,
> And one of the salt sea sand."

After the segregation of the branches represented by Pithecanthropus the erect, the slouching man of Neanderthal and Heidelberg, and the fine-brained Piltdown man, there was left the stem of modern man, which broke up in Pleistocene times into African, Australian, Mongolian, and European races. It is possible that the modern man type was distinguishable from collaterals a million years ago. If we mean by the antiquity of man the time since he reached what may be called the human standard in size of brain, Dr. Keith's conclusion is that this was reached by the commencement of the Pliocene period, which means over a million years ago. When the evidence of flints is considered, the tendency is to go further back still.

There may be errors in the conclusions of the authorities whom we have followed, and the estimates of time are very uncertain, but there is no great likelihood of errors which will affect the general impressions that alone concern us here. The antiquity of man is on a grand scale. There is a solemnity in the patience of the age-long man-ward adventure which has crowned the evolutionary process upon the earth. Three million of years ago the Primate stem sent out its first tentative branches, and the result was a tangle of monkeys; æons passed and the main stem, still probing its way, gave off the Anthropoids, which certainly rise to great heights. There was no pause, however, yet without hurry other experiments were made, and the terminations of these we know at Trinil and Heidelberg and Piltdown, for none of them lasted or was made perfect. Still the main line goes on evolving—and who will be bold enough to limit its insurgence? Is there a race of super-men implicit amongst us who will, when another half million years have sped, look back on us as we on the early Troglodytes? In any case it seems, to say the least, extremely difficult to look back on the sublime spectacle of long-drawn-out trial and error, patience and endeavour, and on the general progressiveness of the issue, without the hypothesis (which other than scientific considerations may make more than a hypothesis) of an inherent purpose as the core of the world-process. But to suppose that the purpose is fulfilled in *us* in particular, who are but stages in an evolving race, seems premature.

§ 3. *Man's Solidarity with the Primate Stock.*

Zoology speaks with no uncertain voice in regard to Man's affiliation to the Mammals. There is "an all-pervading similitude of structure", as Sir Richard Owen said, between man and the anthropoid apes; his blood mingles harmoniously with theirs; he and they share certain diseases. Moreover, man is a walking museum of vestigial structures, which prove his pedigree; and he is shot through with atavistic proclivities. In his development he climbs, to some extent at least, up his own genealogical tree. There is no doubt at all that Man is solidary with the rest of creation. To quote the closing words of *The Descent of Man:* "We must, however, acknowledge, as it seems to me, that man, with all his noble qualities, with sympathy which feels for the most debased, with benevolence which extends not only to other men, but to the humblest living creature, with his

God-like intellect, which has penetrated into the movements and constitution of the solar system—with all these exalted powers—man still bears in his bodily frame the indelible stamp of his lowly origin."

The Psalmist felt Man's insignificance, "When I consider the heavens, the work of thy fingers, the moon and the stars which Thou hast ordained,—What is man?" Subsequent astronomers from Copernicus onwards had taught the same humbling lesson; but it was reserved for the biologists to expose the pit whence Man had been digged, and the rock whence he had been hewn by proving his solidarity with mammals. But this is only one side of the picture.

§ 4. *Man's Unique Position.*

Mankind has often had to pay for the realisation of a great truth by temporarily losing grip of some other. Dazzled by a new conclusion, we are blinded to an old one. Thus, without being reactionary, we may ask whether we have not paid heavily for the truth that is in Darwinism. That truth, as regards Man, was the recognition of his solidarity with the rest of creation, of his definite affiliation to a primitive stock of Primate mammals, of his literal blood-relationship to the relatively distant collateral stock of Anthropoids. It has made the world more a universe to have seen the worm, as Emerson said, mount through all the spires of form, striving to be Man. It has given a new significance to the realm of organisms, with all its groaning and travailing, that the man-child glorious was born of them, bone of their bone, and flesh of their flesh. It has been a clearing of the eyes to know that much that used to seem quite inexplicable and bitterly perplexing in us is a succession tax on our inheritance, a lien that the past dwelling in us exacts. It has been a heartening encouragement to know that it is an ascent, not a descent, that we have behind us, and that if we read the story aright the Cosmos is rather with us than against us. The recognition of our solidarity with the realm of organisms has been of great importance, and we cannot go back on it. Yet it has perhaps blurred our appreciation of Man's apartness.

What, then, are the differentiating characteristics of Man that mark him as a being unique and apart? The bipedal uprightness may have had something to do with human speech, and there is undoubtedly interest in various structural peculiarities from chin to heel (taking both these words with anatomical literalness), and from teeth to great toe, but there is little that we can regard as decisive save the size and complexity of the brain, of the cerebral cortex in particular. No normal human subject has less than twice the cranial capacity of say the orang or chimpanzee; the average human brain weighs far more than twice the heaviest gorilla brain. The closely convoluted cerebral cortex, about a foot and a half square if folded out, is composed of some 9,000 millions of cells, and is the protoplasmic side of Man's capacity for forming general ideas and experimenting with them (in what we call reason), his power of rational discourse or language, his vivid self-consciousness of himself as a personality with a history behind him, and with strong kin-instincts binding him for his own self-realisation to his fellows.

We lose what Darwin has gained for us if we fail to recognise that many animals seem to have a power of perceptual (though probably not of conceptual) inference; that many animals have words though they do not make sentences (perhaps they would speak more if they had more to say); and that there are animal societies at various levels of differentiation and integration. Rousseau's saying, "Man did not make society, Society made man", may be taken to cover the fact of pre-human anthropoid sociality. As Mr. Hobhouse says, "We find the basis for a social organisation of life already laid in the animal nature of man." But allowing all this and more, we are constrained to admit that Man stands to a remarkable degree apart, and that pre-human evolutionary formulæ no longer quite fit.

The theromorphists, who see in Man only a bipedal mammal, are wont to point to children, with their delicious primitiveness of gait and speech, of manners and morals, and with their largely pre-intellectual thought-stream in which the world is "one great booming buzzing confusion"; but while such facts strengthen our conviction of Man's affiliation with mammals, they do not affect our impression of his apartness when a fully developed personality.

We probably err, as Sir Arthur Mitchell never tired of insisting, in dwelling too much on degraded savages, for when we wish to get the truest appreciation of any type we should study its fullest expression, and some at least of the degraded savages are probably in process of retrogression, being the descendants of the under-par remnants of tribes sifted or persecuted too severely. Furthermore, many unsophisticated people take a good deal of knowing and are not quick to lay bare their souls either to missionary or scientific ethnologist.

But our point is the simple one that Man at his best—who reasons and thinks about his thinking, who bends Nature to his will, who seeks after the True, the Beautiful, and the Good with all his heart and soul and strength—is a being singularly apart. As Mr. Hewlett says in his *Richard Yea-and-Nay*: "'Lord, what is man?' cried the Psalmist in his dejection. 'Lord, what is man not?' cry we, who know more of him?"

As the 'self-made' man is proud to show the cottage where he was born, so generic man may take credit to himself in contrasting his present position with his 'humble origin'. He must be very self-complacent, however, if he has no feeling of gratitude in respect of—we cannot say to—those simple creatures without whom he would be yet more imperfect than he is. For while many know the handicap of inherited animal passions sometimes asserting themselves all too vehemently, and of humbling atavisms that come to the surface occasionally from the deep undercurrent of the Unconscious, can there be forgetfulness of the plus side of our inheritance, the deep instincts of kinship, of mutual aid, of love, and of parenthood whose roots go far back into the pre-human world. We must be very careful, too, in inquiring into the accuracy of the statements that are made in regard to what is supposed to be carried on from mammals to men.

The truth lies between two extremes. It is erroneous, on the one hand, to regard man as isolated and the great exception, as "a moral Melchizedek, without father, without mother", and as one who to save his soul must combat the 'cosmic process'. For this overlooks the fact of solidarity, and raises the gratuitous problem how a moral being can have emerged from non-moral or immoral antecedents. It is erroneous, on the other hand, and a fallacious biologism to think that human evolution can be scientifically handled without a recognition of Man as a rational and social personality, pre-eminent even on the average, at his best—and then usually in the form of a woman—"a little lower than the angels, crowned with glory and honour". "What a piece of work is a man! How noble in reason! How infinite in faculty! in form and moving how express and admirable! in action how like an angel! in apprehension how like a God!"

§ 5. *Factors in the Ascent of Man.*

Of the factors in the establishment of human species we are very ignorant, and even speculation has not much to say. Sir Ray Lankester has called attention to the interesting fact that in Miocene times there was a great increase in the size of the brain in several mammal types, such as the Elephants. This may have implied that differentiation of the rest of the bodily system could not profitably go much further. There may also have been some potent environmental stimulation. The possession of a big brain meant great power of profiting by experience, of 'educability', and it would seem that several hundreds of thousands of years ago Man's brain was not far from the standard of historical times, standing head and shoulders above the rest of creation in resourcefulness. But what led to the big brain we do not know. Was there a gradual summation of small increments in intelligence and the like,—here a wrinkle and there a wrinkle in the cerebral cortex, or was there a brusque mutation such as is hinted at in the occasional emergence, in the brief span of historical times, of geniuses, like Aristotle, Archimedes, Shakespeare, and Newton? As regards the big brain, it seems not unlikely that there is shrewdness in Robert Chambers's suggestion that a prolongation of the ante-natal life may have had to do with the big brain, just as the prolonged infancy, characteristic of human offspring, would help in the growth of gentleness. The lengthening of the period of gestation would not of itself mean much in the way of racial advance unless we believe that it could as it were repercuss on the germinal organisation. But it would mean much if there was at the same time a germinal variation in the direction of an enlarged brain. Great importance, as we have seen, is to be attached to 'temporal variations' which consist in altering the 'time' of different periods in the life-cycle, lengthening out here and shortening down there; and the prolongation of youth, also characteristic of mankind and of many very clever mammals, means, as Dr. Chalmers Mitchell has well shown, giving time for breaking down instincts and replacing them by remembered results of experiment, for proving all things, for tentatives in self-expression. It is a significant fact that "Man's brain is only about one-fifth of its adult weight at birth, that of the anthropoid is already two-thirds. . . . By the end of the second year the human brain has reached two-thirds of its adult size, it has then reached the same relative degree of development that the anthropoid has reached at birth" (Keith, *The Human Body,* p. 37).

Consideration must also be given to the possible result of walking erect, of using sticks and stones, of making beds and shelters, of living in families and co-operating socially, of talking a good deal. And all these are illustrated among Primates lower than Man. The Anthropoid Apes are not social creatures, but it must be borne in mind that many of the lower Primates are. There is the raw material of social organisation at many a level among mammals, and there are springs of good conduct, too, which no one need be ashamed to have inherited.

We are ignorant of the factors in the ascent of Man, but we venture to regard Huxley's version of the probabilities as one-sided. "In the case of mankind," he wrote, "the self-assertion, the unscrupulous seizing upon all that can be grasped, the tenacious holding of all that can be kept, which constitute the essence of the struggle for existence, have answered. For his successful progress, as far as the savage state, man has been largely indebted to those qualities which he shares with the ape and the tiger; his exceptional physical organisation, his cunning, his sociability, his curiosity, and his imitativeness, his ruthless and ferocious destructiveness when his anger is roused by opposition." This requires to be corrected by the facts Kropotkin has gathered to show the importance of mutual aid, and by what we know of the indispensableness of the prolonged maternal care and a measure of self-subordination. A clear note was struck by the late Professor Weismann: "It is a perversion of the theory of evolution to maintain, as many have done, that what is merely animal and brutal must gain the ascendancy. The contrary seems to me to be the case, for in man it is the spirit, and not the body, that is the deciding factor." This we regard as good science.

Not very much is known in regard to the factors in the Ascent of Man; but more is known than some agnostics or anti-evolutionists will admit. In illustration of this we venture to refer for a little to the arboreal apprenticeship of the Primates as studied by Dr. R. Anthony and Prof. F. Wood Jones. A new door was opened when the foot became the supporting and branch-gripping member, and the hand was set free to reach upward, to hang on by, to seize the fruit, to hug the young one close to the breast. The evolution of a free hand made it possible to dispense with protrusive lips and gripping teeth, and thus there began the correlated enlargement of the brain-box and the bringing of the eyes to the front. Another arboreal acquisition was a greatly increased power of turning the head from side to side, and many other changes were involved in backbone and collar-bone, in chest and respiration, in hand and brain. "It is the freed hand which is permitted to become the sensitive hand, which now, so to speak, goes in advance of the animal and feels its way as it climbs through life." (See F. Wood Jones, *Arboreal Man,* 1916, and also "The Origin of Man" in *Zoology and Human Progress,* 1919.)

§ 6. *Human Evolution Contrasted with Animal Evolution.*

It is interesting to inquire how evolution-processes in the Kingdom of Man agree with and differ from those in the Realm of Organisms generally. The question is important especially in reference to the view that human history is not only continuous with, but is not more than a continuation of animal evolution. For there is a present-day school who maintain that sociology is only a department of zoology, and that again of dynamics.

There is no doubt that the great facts of variation, modification, and heredity, and the operation of natural selection and isolation are demonstrable in mankind. Albinism is a human mutation, sunburning a human modification, night-blindness a human Mendelian character, in certain diseases there is discriminate mortality or natural selection, and various clans illustrate the influence of isolation. Up to a certain point all is with man as with animal.

The differentia becomes plain when we observe that Man is aware of his own evolution and seeks to direct it according to his ideals. There is no analogue among animals to deliberate selection based on a eugenic ideal. Rational selection transcends natural selection. We cannot accept the suggestion that selective processes in mankind are not exclusively automatic as they are in Nature, for it is an essential part of our argument that they are not wholly automatic in the lower sphere. It was not indeed by taking thought that the ancestors of leopards changed their spots so that their descendants had a garment of invisibility when crouching in the dappled light of the forest, but it may have been at least horse-sense that led their descendants to form a habit of choosing the places where the illumination suited them. We have already argued that whenever an animal takes an active share in its own evolution, the process ceases to be wholly automatic. What differentiates man is his attempt to control his evolution according to an ideal. A rational and sometimes an ethical note is sounded.

We may give another illustration of our meaning. Isolation and consequent inbreeding have probably meant a good deal in a purely biological way in fixing the dominant characters of tribes and stocks. But the facts of history warrant us in saying that it is a false simplicity to omit as a factor in the unification, at least as important as the bonds of kinship, the unanimism wrought out by a common hope or ambition. It is a fallacious biologism to think that human evolution can be accounted for without a recognition of Man as a rational and social personality.

The first reason why we cannot regard the history of human societary forms as simply a continuation of infrahuman organic evolution is that in society we have to deal with integrates which work as wholes apart from the function of the component individuals. An approximation to this on the instinctive plane of evolution is to be found in the bee-hive, in ant-hills, and in termitaries. A far-off hint of it on the intelligent plane is to be found in the beaver village and the band of monkeys.

Professor McIver has argued very clearly that in mankind there are no individuals who are not social individuals, and that a society is not other or more than the members who compose it. The social relationships of every individual are not outside him, they are aspects of his individuality. There is no social function which is other than the functions of personalities.

We agree that there is no mysterious entity which we call a society, or a social integrate, or a societary form; that each is composed of a number of more or less like-minded and like-bodied individuals. But we are inclined to think that Mr. MacIver's recoil from a false antithesis between society and the individual, leads to an under-appreciation of the difference that social life makes. When men are associated and organised and integrated, their corporate behaviour does not follow as a matter of course from what we know of them as individuals. There is a strange psychology of the crowd. The same holds true of animals, to whom it is always a relief to turn. Termites sometimes go on food-collecting forays, 300,000 in a vigorous band, about 200 soldiers to 1,000 workers. At critical places the soldiers form a guard for the foragers; they give signals, they act as scouts, they keep or restore order. If they lose their presence of mind and fall back among the workers there may be a panic. Here, on an instinctive line, is social organisation, and our point is simply that, when integrates of individuals act as units of a higher order, a new complication is introduced. This complication is necessarily much greater in mankind where social tradition counts for much, and where the integrates, such as communities or nations, that now and again rise to some glorious expression of unified life, are not comparable to species or to varieties of animals, but are united by bonds quite different from those of blood-relationship. Two nations at war are not closely comparable to two species of animals in internecine competition, if we admit that there are secure instances of this to be found. One difference is that a nation is not a kin-unit as a species is, and another difference is that the issue of the struggle depends in part on extra-individual factors, such as wealth, and there are other differences.

The second differentia concerns the nature of variations. In the Realm of Organisms variations count only in so far as they are continued in the germ-plasmic inheritance of descendants. In the Kingdom of Man this is true as regards organic qualities, but it is not true as regards the influence of the movers and shakers of the world, nor as regards another kind of societary variation, such as a sudden change from an Imperial dynasty to a republic, or any re-organisation of institutions after disasters or clashes. In human society extra-organismal variations bulk largely.

The third differentia is illustrated in the predominant rôle of the social heritage. For racial progress in physique and mental vigour what counts is the natural inheritance, the germ-plasm. For societary progress in good will, in discrimination, in adjustability, in appreciation of the beautiful and so on, what counts is also the natural inheritance, but of vast importance as well is the extra-organismal heritage, the social heritage of literature and art, the folk-ways of customs and tradition, the external registrations which we call institutions.

The fourth differentia is to be found in the ethical quality of certain forms of social selection, which sound a new note.

In ordinary affairs a feckless unreliable person who is very delightful in many ways, but cannot be trusted to keep appointments, gets left automatically. The traditions of business-likeness, the social systematisations, make him impossible, and he is elbowed out as a failure. This is closely comparable to the process in Nature by which a variant that is incompatible with the external systematisations gets sifted out. But there is in society another and distinctive kind of sifting which works potently for good and ill, where a social ideal of some sort is defined, and organisations are formed, both on the temporal and spiritual side, to realise it. There is deliberate controlled selection and its instruments are integrates, not individuals.

It seems, then, that in societary variations, apart from those due to the great men; and in social extra-organismal heritage, apart from all germ-plasm; and in societary selection, apart from natural selection in society, new notes are sounded, which forbid any false simplification of the facts, which in sociology is called a biologism and in biology a materialism.

Hear, then, the conclusion of the whole matter. There are some who think human society is just a new edition of the animal community or of the alleged animal gladiatorial show, and *they* are wrong. There are others who think human society is on a plane wholly apart, a little lower than that of the angels, where all talk of germ-plasm and other abominations of the breeding-pen is irrelevant, and *they* are wrong.

The truth is between the two extremes, and the whole truth has not yet been revealed. We have given attention to the contrast between organic evolution and social history because inattention to such contrasts is the theoretical complement of fumbling and muddling in practical affairs.

For practical purposes the most important feature of the contrast we have been working at lies in the rôle that the extra-organismal plays in the history of human society, and here we venture to quote a striking passage from a well-known evolutionist, Dr. Chalmers Mitchell, the secretary of the Zoological Society of London.

We are familiar with Kant's beautiful passage beginning: "Two things fill my mind with ever renewed wonder and awe the more often and deeper I dwell on them—the starry vault above me, and the moral law within me."

"We may well agree," says Chalmers Mitchell, "that the starry vault is a supreme example of the reality and externality of the physical universe. . . . I assert as a biological fact that the moral law is as real and as external to man as the starry vault. It has no secure seat in any single man or in any single nation. It is the work of the blood and tears of long generations of men. It is not in man, inborn or innate, but is enshrined in his traditions, in his customs, in his literature and his religion. Its creation and sustenance are the crowning glory of man, and his consciousness of it puts him in a high place above the animal world. Men live and die; nations rise and fall, but the struggle of individual lives and of individual nations must be measured not by their immediate needs, but as they tend to the debasement or perfection of man's great achievement" (1915, p. 107).

§ 7. *In What Sense May It Be Said that Nature Is Crowned in Man?*

It may be said that Man is the outcome of a persistent trend—towards freedom of mind—which has been characteristic of the process of organic evolution for millions of years. A Martian zoologist, on another line of life altogether, would, we fancy, have said in his report on a scientific expedition to our planet in Eocene times, that the Sauropsidan line of evolution had been crowned in the peopling of earth and sky with a fascinating set of bipeds, of quaintly engaging ways and consummate locomotion, with adorable parental virtues and an extraordinarily high level of artistic culture which seemed to be quite instinctive to every one of them, and so pervasive that many of them could not perform the commonest offices of life, without investing them with grace. He was reporting on Birds, of course.

But is it not justifiable, in an equally detached way, to say of Man that he crowns one line of Mammalian evolution? He shows in notable excellence what his predecessors, both direct and collateral, have moved slowly towards,—a large and intricate cerebral cortex, a subtle integration of the body, and a masterly resourceful behaviour.

We cannot suppose, with the scholars in the school of 'Naturalism', that the only realities are those that Natural Science deals with, but we are not sure that Mr. Arthur J. Balfour is accurate when he speaks of Man being, according to Naturalism, "no more than a phenomenon among phenomena, a natural object among other natural objects, his very existence an accident, his story a brief and transitory episode in one of the meanest of the planets". For even from the position of 'naturalism', it does not seem justifiable to call Man's "very existence an accident". There may be accidents in evolution, though we think there are few, but they do not last for two millions of years. An ascent that has probably occupied between two and three millions of years is not well described as "a brief and transitory episode". Man may have been the greatest of mutations, but there is no scientific warrant for regarding him as a freak. He is congruent with antecedent and collateral evolution towards higher nervous organisation.

In the same way we cannot admit that Huxley was talking good science when he insisted that Man's only chance of ethical progress was to combat the cosmic process. He made this antithesis because he saw in Nature a vast gladiatorial show, a ubiquitous Ishmaelitism, every living creature for itself and extinction taking the hindmost. He made man a stranger in Nature by failing to appreciate adequately the fact that throughout the struggle for existence in Nature there is often a pathway to survival and success through increased co-operation, kindness, and mutual aid, as well as through increased competition and self-assertion. Along the line of combination and mutual aid Man has made some of his greatest advances, and this line was indicated, as it were, by Nature to him.

We have already asked whether there is not an ethical finger-post in Nature's strategy that the individual living creature realises itself in its inter-relations, and has to submit to being lost that the welfare of the whole may be served. There is much indeed to be said for the thesis (which Prof. Patrick Geddes has maintained) that the ideals of ethical progress—through love and sociality, co-operation and sacrifice, may be interpreted as the highest expressions of the central evolutionary process of the natural world.

Taking a broader than scientific view, we recognise that there are other ways in which it may be said that Nature is crowned in Man. He is Nature's interpreter, rationalising the whole. In him the inherent rationality of Nature, the Logos, became articulate, and found, moreover, joyous appreciation.

We cling to the Aristotelian doctrine of the End as the philosophical explanation of what goes before. As Prof. A. S. Pringle-Pattison puts it in his Gifford Lectures, "The nature of a power at work in any process is only revealed in the process as a whole. It is revealed progressively in the different stages, but it cannot be fully and truly known until the final stage is reached. . . . Now man is, from this point of view, the last term in the series, and the world is not complete without him." We are grateful for what seems to us wise teaching, but we venture to suggest that in regard to a race and an external heritage that may go on evolving for millions of years to come it is premature to speak of 'final stage' or 'last term'.

SUMMARY.

There are in the Realm of Organisms many masterpieces, reaching along diverse lines to approximately equal heights of differentiation and integration. Thus many insects in their way attain to extraordinary perfection. Yet no one hesitates in ranking birds and mammals as much 'higher'. This means that they excel in being very highly differentiated and integrated, but also that they exhibit the fullest expression of what the trend of evolution seems to make for, namely, freedom, mastery, and joyous consciousness. We call them "higher" for two objective reasons, but we colour these with an appreciation of values.

With inconceivable slowness the evolving stock of Primates was differentiated along distinct lines. New World monkeys, Old World monkeys, small anthropoids, and large anthropoids were in turn segregated off. The evolving human stem was further pruned by the divergence of doomed races,—Pithecanthropus, Neanderthalers, and perhaps the men of the Sussex Weald. It is perhaps a million years since the human standard of brain was reached.

In Man's bodily structure there is an all-pervading similitude with the higher Anthropoids; his blood mingles harmoniously with theirs; he is a museum of relics in the form of vestigial structures and he is shot through with atavistic proclivities; in his development he climbs up his own genealogical tree. Man is solidary with the rest of creation.

On the other hand, Man is quite unique in his capacity for forming and experimenting with general ideas or concepts (reason), in his power of reasoned discourse (language), in his vivid consciousness of himself as a personality with a history behind him and with strong kin-instincts binding him for his own self-realisation to his fellows. Man is apart from the rest of creation.

Of the factors in the establishment of human species we are very ignorant. A great increase in brain capacity, implying marked educability, perhaps arose as a mutation, as genius does still. Perhaps a temporal variation, implying a prolongation of antenatal life, infancy, and childhood, was of importance. Also to be considered are the results of arboreal life, of the emancipation of the fore-limb, of walking erect, of using sticks and stones, of building shelters, of living in families, of talking a good deal—and all these began in Primates lower than Man. Furthermore, there were a good many experiments in social organisation prior to Man.

Human history, though continuous with, is more than a continuation of animal evolution. Man is a rational and social personality, understanding something of his own evolution and seeking to have a hand in it, directing it in reference to an ideal. When the factors in social history are compared with those of organic evolution, great differences appear. In society we have to deal with integrates which work as units, in a manner which cannot be adequately described in terms of the functions of the component individuals. In social evolution enormous importance attaches to the extra-organismal,—to societary variation, to the social heritage, and to deliberate social selection by social methods.

In what sense may we say that Nature is crowned in Man? He is the outcome of a persistent trend towards dominance of mentality, and he carries this to finer issues. Man cannot be regarded as 'accidental' or 'episodic'; he is the outcome of a long-continued orthogenesis. Man is Nature's interpreter, rationalising the whole. In him the Logos became articulate, and found, moreover, joyous appreciation. To Man also it has been given in an extraordinary degree to control Nature's operations for his own purposes. He has often put more meaning into Nature by mastering it.

LECTURE XVIII.

DISHARMONIES AND OTHER SHADOWS.

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§ 1. *Difficulties in the Way of a Religious Interpretation of Animate Nature.*

Science has strictly to do with the operations which go on in Nature. It may legitimately inquire, indeed, into the purposes that prompt the efforts of the higher animals, or into the means by which certain results have been achieved, but it has not to do with the problem of the meaning of Evolution. Metaphorically we have occasionally spoken of the tactics of Nature, notably the great trial and error method of Natural Selection, but we confess that this is leaving strictly scientific terminology. And if the metaphor of 'tactics' be allowed to pass, we must not offend by speaking of strategy. Yet as rational beings we insist on pushing beyond science to a more all-round or synoptic view which inquires into the significance of things and of organic evolution in particular. That organic evolution has led on to Man is certain—the only known organism to understand it a little; the general trend of organic evolution is integrative and towards what at our best we value most—goodness, beauty, and the health that leads to truth; there is, we maintain, a scientifically demonstrable progressiveness: these and other considerations give us what we may call a scientifically justified expectancy of discovering significance. But it is through other paths of experience that men come to believe —if they have the will to believe—in there being a strategy behind evolution, which is partly what believing in God means. Given, in other than scientific experiences, some conviction of an increasing purpose, ultimately spiritual in content, the question rises whether the state of affairs in Animate Nature and the way in which this has come about is congruent with a religious interpretation.

We repeat that a scientific survey of the system of which we form a part cannot prove anything as to the significance of the whole; that is certainly not its *métier;* yet it is legitimate to ask whether the impressions afforded by the scientific survey are consistent with regarding Nature as the expression of a Divine Thought or Purpose. But it is often said that this consistency can be recognised only by those who are willing to ignore the seamy side of things. Let us therefore face some of the disharmonies and shadows.

§ 2. *Extinction of Highly Specialised Types.*

One of the shadows which cannot be ignored is the lack of plasticity in highly specialised types. The physical world is changeful, in climate, in weather, in surface-relief, and there are many living creatures which are unable to change with it. They have gone too far to tack, and they perish. Adaptations to novel conditions abound, but the over-specialised are sometimes victims of their own perfection. Many types of great excellence have thus passed away without leaving any direct descendants. The graceful Graptolites, the robust Trilobites, the highly specialised Eurypterids, the great Labyrinthodonts, Ichthyosaurs, Plesiosaurs, and the

Pterodactyls that could fly, are such lost races, not continued into other stocks, wonderful achievements, but lacking in plasticity. As the palæontologist Marsh said, the epitaph of the Iguanodon might be, "I and my race died of over-specialisation", and he might have added 'and stupidity', for there was not in these ancient giants the intellectual resourcefulness which we see in the still more specialised modern birds who can adapt themselves to many a drastic change.

We must admit that the extinction of splendidly perfect types raises strange thoughts. What can one say save that every art is limited by its medium, and that here the medium is twofold, the inorganic and the organic? The inorganic world is the grindstone on which life has been whetted, and it cannot become a soft cushion. An environment without vicissitudes might have meant an unprogressive fauna and flora of jellyfishes and seaweeds. Against the callousness of the inorganic domain, moreover, we should remember, though with dread of a circular argument, the other fact that the physical conditions are singularly well suited to be a home of living creatures. Moreover, the lack of plasticity in organic structure is the minus side of that stability which marks the journey-work of millennia. What is stable cannot also be labile. Furthermore, some of the gains of lost races may be continued on collateral lines.

§ 3. *Imperfect Adaptations.*

Another shadow is the existence of imperfect adaptations. These are of two kinds. First, there are established arrangements which work well on the whole, but now and again break down or miss the mark, as is the case with tropisms and instincts that are in ninety-nine situations adaptive, but in the hundredth suicidal. The crepuscular moth, unaccustomed to light, flies into the candle, and the lemmings on the march seeking new territory swim out into the North Sea and are drowned in thousands. But the most keen-scented discoverer of disharmonies or 'dys-teleologies' will surely not suggest that organisms should be adapted for unusual exigencies rather than for the routine of daily recurrence. Even when there are adaptations to peculiar exigencies, as we see in the surrender of damaged parts and their regrowth, these exigencies are of frequent recurrence.

There are instances, however, of structures that do not seem to work so well as we have got into the way of expecting from organisms. Thus attention has often been directed to the cumbersome twenty feet of intestine with which man is burdened without corresponding compensation. It may be doubted, however, whether much of a case can be made of any of man's disharmonies, since he is evidently in process of rapid change of habits. An organism originally adapted to feed when he could rather than when he would, must not complain too loudly if he is not perfectly adapted for absolutely punctual and well-proportioned meals.

In the case of some trees which spread their roots horizontally at a slight depth it not infrequently happens during a storm that the pressure of the wind on the branches causes a strain too great for the roots to stand. The tree falls, though in perfect health. This violent death reveals an undoubted imperfection, but it also shows how physical conditions eliminate such subtle defects as lack of proportion between spread of sail and strength of mast.

§ 4. *Disease.*

Those who would arraign Nature on the charge of tolerating disease may be almost dismissed from court. For, apart from parasites and senescence, there is almost no disease in wild Nature. Should a pathological variation arise, and that seems a rarity, it is eliminated before it takes grip. Disease in the system of Nature is a contradiction in terms. Constitutional disease is the occurrence of a metabolism out of place, out of time, and out of tune, and Nature makes short work of such idiosyncrasies.

What, then, of potato disease and salmon disease, of fowl cholera and swine fever, of big-bud on our currant-bushes and bee-disease in our hives? The list may be lengthened out, but the answer is the same for all, that these diseases occur in artificial, humanly contrived conditions, not in the system of wild Nature with which we are here concerned. It is doubtful whether there are more than two or three examples of microbic disease in natural conditions, one of the best known being a bacterial disease in sandhoppers, and this may have something to do with sewage, as salmon-disease with polluted rivers.

It is not asserted, however, that wild animals may not be infected with microbes so that an epidemic results. What is maintained is that such occurrences are exceedingly rare and transient, and that they are usually traceable to rapid human interference,—to introducing new tenants into a region, to killing off the natural eliminators of the sickly, to permitting over-crowding, to an infection of the soil and water, and so forth.

What of a familiar case such as grouse-disease? The facts appear to be that grouse harbour a good many parasites which normally do them no appreciable harm. When birds of inherently weakly constitution appear they are normally eliminated by golden eagles, stoats, and other natural enemies; and the standard of the stock is not lowered. If overpreserving, *i.e.*, careless elimination of the natural enemies, removes the natural sieves, then birds of weakly constitution tend to become more numerous with each year, till a bathos of weakness is reached. The contingent of parasites which seems to be kept within limits in the vigorous bird may then increase sevenfold, spreading, for instance, to new organs, and this may give the death-blow. It seems that there is no specific disease in this well-nigh sacred bird, and it is highly probable that there would be no 'grouse-disease' if there were no game-keepers.

§ 5. *Parasitism.*

One of the shadows on the pleasant picture of animate nature is the frequency of parasitism. To some minds it appears as a blot spoiling the whole script. But without denying that there is some warrant for practical, æsthetic, and ethical recoil, we think that much of this is due to lack of perspective. Let us briefly consider the facts of the case.

(*a*) Thousands of living creatures live in or on others, bound up with them in brutally direct nutritive dependence, and incapable of living in any other way. Uninvited and non-paying boarders they are, who make their hosts no return for the hospitality enjoyed. Most animals that have bodies at all have parasites in or on them, and the same is true of most of the higher plants which are the hosts of moulds and rusts, gall-producing creatures, and burrowing larvæ. One of the European oaks harbours no fewer than ninety and nine different kinds of gall-flies, and the hundredth is probably being discovered. The lac insect of India is attacked by thirty-one species of plant and animal parasites. The dog is a terrain for over forty parasites; man and pig have far more. In fact when we inquire into the number of diverse parasites that may possess a lusty host, with a wide range of appetite, we find that they are legion like the demons. When we ask about the number of individual parasites, it is beyond telling.

(*b*) In many cases the association of parasites and host is very specific, that is to say, many a parasite is only known to occur in one definite kind of host, and many a host is curiously non-susceptible to parasites not very different from those which it harbours. The larvæ of some of the fresh-water mussels cannot become parasitic except on definite species of fishes, though the larvæ of some other kinds can utilise many fishes. The larva of the liver-fluke in Britain cannot develop except in one species of water-snail (*Limnæa truncatula*), though in other countries other species sometimes serve. There are, however, some very cosmopolitan parasites which occur in many hosts.

(*c*) Parasitism is a relation of dependence—always nutritive, often more—between the parasite and the host, but it occurs in many grades. There are superficial ectoparasites which often retain great activity, and intimate endoparasites which may become practically part of their host. There are partial parasites which retain independence during some chapter or chapters of their life, and total parasites which pass from host to host and are never free. Sometimes, it is only the female that is parasitic, the male remaining free.

(*d*) Corresponding to the degree of parasitism is the degeneration of the parasite. This is sometimes to be witnessed in the individual lifetime, *e.g.*, in many Copepod Crustaceans where the young are free-living. In other cases it may be inferred by comparing the parasite with related free-living types. The retrogression affects especially the nervous, sensory, muscular, and alimentary systems. The reproductive system is often highly developed and the multiplication very prolific, which may be associated (*a*) with the fact that the parasite is often living without much exertion, with abundance of stimulating food at its disposal, and also (*b*) with the probability that as the chances of death are often enormous, non-prolific forms have been persistently eliminated. Parasites survive not because they are strong, but because they are many.

(*e*) While there are many different types of parasites, it is of interest to notice that some kinds of organisation are not compatible with a parasitic mode of life. Among backboned animals the only parasite is the hag (Myxine) and it is not thoroughgoing. There are very few parasitic Molluscs or Cœlentera, and there are no parasitic Echinoderms, partly perhaps because the life of these three types is very dependent on the activity of ciliated cells which usually require fresh water-currents. Among plants, most of the parasites are Fungi and very few are Flowering Plants.

(*f*) The life-histories of parasites are often very intricate and full of risks. In many cases two hosts are required. The embryos of the liver-fluke pass from sheep to water-pool; the hatched larvæ enter a water-snail; there are several asexual generations in this first host; minute flukes leave the snail and encyst on blades of grass; if these are eaten by a sheep —the second host—the cycle recommences. There are curious cases of hyper-parasitism where one parasite contains a second which contains a third, and this gives rise to complicated life-histories.

(*g*) Thoroughgoing parasites, with a long evolution behind them, are naturally enough well-adapted to the conditions of their life. Thus a tapeworm in the intestine of its host absorbs food by the whole surface of its body; it has muscular adhesive suckers and sometimes attaching hooks; it can thrive with a minimum of oxygen; it has a mysterious 'anti-body' which prevents it being digested by its host; it is exceedingly prolific; and it is self-fertilising. The tapeworm may be ugly, but it is very well-adapted; it may be repulsive, but in the technical biological sense, relative to the given conditions, it is 'fit'.

Such are a few of the most important facts in regard to parasitism. Let us now inquire why the prevalent inter-relationship seems to many a dark shadow. Parasitism is repulsive for three reasons: (1) because we dislike to see fine organisation devastated, (2) because many parasites produce an unpleasant æsthetic impression, and (3) because the life of ease and sluggish dependence grates on our ethical sense or on our idea of an organism.

(1) Many people resent the fact that a contemptible microbe may kill a genius before he comes of age, and that paltry flies put a drag on the wheel of the chariot of civilisation. It is abhorrent that fine organisation should be spoiled by intrusive parasites, but it is necessary to look all round the facts. (*a*) In a multitude of cases the parasites do not greatly trouble their hosts, a *modus vivendi* has been established. If the host be of a weakly constitution or enfeebled by lack of food, the parasites hitherto trivial may get the upper hand and bring about the death of the host. But this sifting will make for racial health, and cannot be called abhorrent. (*b*) Mortality from parasites is in most cases a consequence of organisms entering a new area and becoming liable to attack by creatures to which they can offer no natural resistance, or a consequence of the introduction of the parasite into a new area where it finds new hosts abnormally susceptible to it. Cattle introduced into a

tsetse-fly belt are fatally infected by a trypanosome which does not seem to damage the native antelopes in which it is, so to speak, at home. The fatality of a new microbe introduced into a new population is familiar, as in the case of the Black Death in England, which was due to the introduction of the microbe of bubonic plague.

It must be remembered that the effect of the parasite on the host is extraordinarily varied. Some give off toxic substances; others cause lesions and inflammation, especially if they stray from their usual habitat in the body; some promote beautiful growths like oak-apples and pearls; others drain the food-supply; some do very little harm. The sturdie-worm causes locomotor disorders in the sheep in whose brain it grows, but the Gregarines found in the reproductive organs of most earthworms seem usually unimportant in their effects. The parasitic crustacean known as Sacculina destroys the reproductive organs of crabs and changes the male constitution towards the female type, so that a small ovary may develop. The shape of the crab's abdomen changes, approximating to that of the female, and the protruding parasite is actually guarded by its bearer as if it were a bunch of eggs. But many ' fish-lice ' seem to do very little, if any, harm to their bearers. It is highly probable that very aggressive parasites have eliminated themselves from time to time by killing their hosts, which it is not to a parasite's interest to do.

(*c*) It seems useful to place by themselves parasites like virulent Bacteria (*e.g.,* the Plague Bacillus) and virulent Protozoa (*e.g.,* the Trypanosome of Sleeping Sickness) which are rapidly fatal when transferred to a new kind of host. Thus the Plague Bacillus is transferred by the rat-flea from the rat, who can stand it, to man who has no constitutional defence against it. Similarly, the tsetse-fly transfers the trypanosome from some immune wild animal (such as an antelope, it may be) to the highly susceptible man. But these microbes are not in any special way adapted to parasitic life; they might as well be called *predatory*. Many predatory parasites, like Trypanosomes, live an exceedingly active life within their host, exerting themselves as much as many a free-living creature.

(2) Many parasites are æsthetically repulsive in form, colour, and movements, and it is interesting to contrast the attractive free stages of some of them with the ungraceful bloated parasitic stages. As we have already seen, the ugliness is the brand of their degeneracy. It is the natural result of retrogression, sluggishness, and over-feeding. The life of ease drifts and it loses the grace of the sharpened life which commands its course. The dodder and mistletoe, which every one must admit to be beautiful, are, it is interesting to notice, only partial parasites. The ugliness of some parasites is perhaps an exception that proves the rule; it is as if Nature said: This asylum is open, if you will, but if you enter, you must wear the livery of dishonour; beauty will disappear.

(3) To many minds, however, the darkness of the shadow is in the inconsistency between the parasitic mode of life and Nature's usual insistence on a strenuous life, and this has to be admitted. But one must remember how parasitism arises in the struggle for existence. Environing limitations and difficulties press upon the organism and one of the solutions which is open to many is to evade the struggle by becoming parasitic. The struggling, endeavouring creature cannot have a clear prevision of the *facilis descensus* it has set foot on. It may try to survive inside a larger organism

which has swallowed it; in its searchings for food and shelter it may discover what is to it simply a new world—on or beneath the surface of another organism. It is not another organism to them as it clearly appears to us; it cannot be separated off from other areas of safety and abundance which other struggling organisms may secure.

It is exceedingly difficult to draw a dividing line between some parasites which are of some slight use to their hosts, *e.g.,* the beautiful Infusorians in the stomach of some herbivores like horse and cow, which seem to help in breaking down the food, and certain symbions or commensals which are on the whole useful, but levy a slight tax. Some ectoparasites behave as if it was their duty in life to keep the surface of their host's body clean. All the three modes of life are to be looked at as expressions of the widespread tendency in Animate Nature to establish inter-relations between organisms, to link lives together, to weave a web of life. It may be occasionally repulsive, but it is to be considered broadly as a part of a complex external systematisation or correlation that has been evolved in the course of ages and is of great importance in the process of Natural Selection.

It must not be forgotten that parasites occasionally play a part as eliminative agents, and may work towards conservation as well as wastefully. They may weed out the weakly members of a stock. They may put a useful check on abrupt changes of distribution. Another exonerating fact is that in a number of cases, *e.g.,* among Crustaceans, the parasitism is connected with the continuance of the race, and is altruistic as much as egoistic, for it is confined to the mother-animals, who seek a safe place in which to bring forth young.

(4) It must be admitted that there is an occasional hint

of 'wildness' about parasitism, just as about some other ways of life. No explanation can be offered except that organisms have in them something akin to the artist's genius. They have endless resources and they are free. Some have explained that it is not the destructiveness of parasites they object to, nor their ugliness, nor even their feckless drifting life, but their devilishness. The ichneumon-fly lays her eggs in a caterpillar; the hatched grubs feed on the living tissues; they make their way out to begin a new phase of life after they have killed their host. It is very difficult, however, to avoid anthropomorphism in such cases. Perhaps it does not matter much to the caterpillar whether it is devoured from the inside or from the outside, and perhaps the ichneumon larvæ should rather be called beasts of prey than parasites. In any case it is certain that what the ichneumon-insect does to the caterpillar is not so repulsive as what man often does to man, for man knows or should know what he is doing. In both cases there is devilry, but the ichneumon's is unconscious. Moreover, it plays a very important rôle in the extraordinarily well equilibrated economy of Nature.

§ 6. *Cruelty of Nature.*

The system of Animate Nature is evolved on the scheme that many kinds of living creatures use others as food. If this be cruelty, then Man is in it too. But in most cases there is no reason to drag in the idea of cruelty; taken in the strict sense the word does not and cannot grip.

It should be remembered, if it makes any difference, that many animals are vegetarian and that many depend upon organic débris. Thus great hordes of marine animals live on the detritus washed outwards and downwards from the littoral vegetation of Algæ and sea-grass. That all living creatures should have pursued the plant régime of living on air, water, and salts is conceivable, but it would not have been an adventurous resolute world, for the vigorous higher life depends on a supply of high explosives manufactured by other creatures. If animals had had to manufacture their own munitions as plants do, there would not have been much fighting, but there would not have been much thinking either.

But the critic of Nature explains that it is not the carnivorousness that offends him,—he does a little in that way himself—it is the manner of its accomplishment. The gentle disciple of Izaak Walton is pained that the Fishing-Frog should use a rod and line. The housewife who sets a trap for mice in the pantry affects to shudder at the ant-lion which makes a pitfall for unwary insects. There is a taint of insincerity about all this exotic tender-heartedness. The joy of the cat is the grief of the mouse, says a Russian proverb; but we go a-fishing with a light heart. We are of more value than many trout. We do not deny that there are some difficult cases, like that of the cat playing with the mouse, which has perhaps an educational significance—and what may not be done in the name of education—but in the great majority of cases violent death is rapid and probably painless, and the accusation of cruelty is an irrelevant anthropomorphism. We do not deny that there are what look like dark shadows in Animate Nature, but we have seen some of them disappear in the light of fuller knowledge, and we think that William James was on the whole misled by unawareness of the facts, when he wrote of Nature—to some of us an alma mater—as "a harlot", "all plasticity and indifference", "a moral multiverse and not a moral universe". "Beauty and hideousness, love and cruelty, life and death keep house together in indissoluble partnership; and there gradually steals over us, instead of the old warm notion of a man-loving Deity, that of an awful power that neither hates nor loves, but rolls all things together meaninglessly to a common doom." But this seems to us a terribly alarmist inference to base on a demonstrably inaccurate study of Animate Nature. It is not really the case that beauty and hideousness, love and cruelty, keep house together in indissoluble partnership.

We must confess, however, that even the naturalists are often against us. Thus the veteran John Burroughs writes in his charming *Breath of Life:* "What savagery, what thwartings and delays, what carnage and suffering, what an absence of all that we mean by intelligent planning and oversight, of love, fatherhood! Just a clash of forces, the battle to the strong and the race to the fleet." Are we not all like perplexed privates writing bitterly of a campaign, knowing little of the actual operations, still less of the tactics, and nothing of the strategy? There are no doubt terrible minutes when two lions get the better of an antelope, or the wolves close in upon the deer, and huntsmen like Selous have spoken of the "frenzy of fear and agony of a dying brute". But we must beware of anthropomorphic exaggeration. We recall Mr. Louis Golding's good-humoured rebuke (1919):

> "But if a moth should singe his wings,
> The world is black with dismal things.
> And if a strangled sparrow fall,
> There is not any God at all."

Alfred Russel Wallace had wide experience of wild nature, and wrote: "Animals are spared from the pain of anticipating death; violent deaths, if not too prolonged, are painless and easy; neither do those which die of cold or hunger suffer much; the popular idea of the struggle for existence entailing misery and pain on the animal world is the reverse of the truth." Similarly Darwin concludes his chapter on the "Struggle for Existence" with the sentence: "When we reflect on the struggle, we may console ourselves with the full belief that the war of nature is not incessant, that no fear is felt, that death is generally prompt, and the vigorous, the healthy, and the happy survive and multiply."

We must beware of anthropomorphic exaggeration, but we must also beware of commonplace inaccuracy. The death-crisis of a mouse killed by a rattlesnake was 13 seconds; the death-crisis of a thrush killed by a golden eagle was less than half that.

We frankly admit, however, that for some reason or other many of the forms of life are weird and fantastic creations, and there is often more than a hint of the "wildness" of which Prof. William James spoke. The solitary wasp Philanthus, known as the bee-eater, catches bees and after giving the victim a knock-out blow beneath the chin and paralysing it, proceeds to knead its anterior body, squeezing out the honey from the crop and enjoying the grim meal. But if instead of turning away repelled we follow the Philanthus, we find that the body of the bee is used as provender for the larvæ whose hatching the Philanthus does not survive to see. We may rest satisfied with this without following the famous entomologist who has told us that the kneading operation which squeezes the honey out is not so much for the parent's immediate gratification as to prevent the larva from having stomach-ache.

§ 7. *Senescence and Death.*

Another shadow is senescence and death. It saddens us to see a fine edifice falling into ruins, and though old age is often beautiful in mankind, the time comes when even beauty goes. Let us recall the picture which we owe to the author of Ecclesiastes: The mind and senses begin to be darkened, the winter of life approaches with its clouds and storms, the arms—the protectors of the bodily house—tremble, the strong legs bow, the grinders cease because they are few, the apples of the eyes are darkened, the jaws munch with only a dull sound, the old man is nervously weak and startled even by a bird's chirping, he is afraid of even hillocks, his falling hair is white as the strewn almond blossoms, he drags himself along with difficulty, he has no more appetite, he seeks only his home of rest, which he finds when the silver cord is loosed or the golden bowl broken.

There is something indescribably pathetic in the decline and the decay when it passes beyond senescence into senility. The bones become lighter and less resistant, the muscles weaker and stiffer, the nervous system slower and less forceful, the heart less vigorous, the arteries less elastic, the parts fail to answer to one another's call, "and then, from hour to hour, we rot and rot".

In regard to this dark shadow, it must first be pointed out that the securing of a healthy old age is very largely within man's control, everything depending on the nature of our physiological bad debts. Many are successful in securing an old age such as Cicero praised; others have one whose days are labour and sorrow. In recent times, the late Professor Metchnikoff has been prominent in maintaining that if man led a more careful life, and had a more enlightened understanding of the limitations and disharmonies of his constitution, he would no longer, as Buffon said, die of disappointment, but would attain everywhere a hundred years.

The second point is not less important. As Professor Humphrey, a specialist on old age, has said, "Strange and paradoxical as it may seem, this gradual natural decay and death, with the physiological processes which bring them about, do not appear to present themselves in the ordinary economy of nature, but to be dependent upon the sheltering influences of civilisation for the opportunity to manifest themselves, and to continue their work." The fact is that man and some of his domestic animals have almost a monopoly of senility, while wild animals rarely show a trace of it. Thus senility is not disharmony in Nature, but in the Kingdom of Man.

The bathos often seen in man is due partly to the way in which he shelters himself from violent or extrinsic death, which cuts off so many—if not most—animals; partly to the unnatural ways in which he lives; and partly to his deficiency in the resting instinct.

It is instructive to probe the matter further, inquiring into the reasons not for senility, but for senescence and natural death. There is an obvious distinction between (*a*) death due to microbes or parasites, (*b*) death due to extrinsic agencies or violence, and (*c*) death due to internal constitutional reasons; it is with the last, natural death and its antecedent senescence, that we have to do. To the question: Why should an organism grow old?, many answers have been given. A reason has been found in the wear and tear of parts, especially of elements like nerve-cells, which do not in higher animals increase in number, nor admit of renewal, after early stages in development. We do not get any additions to our nerve-cells after birth. But why might not nerve-cells have retained the power of regeneration that they have in some of the lower animals?

A reason for old age and natural death has been found in the slow accumulation of poisonous waste-products, of the results of incomplete combustion, of the results of bacterial activity, and so on. The fire of life may be smothered in its own ashes. But it must be recognised that there is no necessity for this, that we can conceive of more perfect arrangements for purification. Isolated pieces of tissue can be kept for a long time living if waste-products are carefully eliminated. Similarly it has been pointed out that ageing is associated with the diminishing activity of glands of internal secretion, with a cumulative disproportion between cytoplasm (cell-substance) and nucleoplasm, with the occurrence of organically expensive modes of reproduction, and so on. But these suggestions seem to disclose what are merely symptoms of some more fundamental imperfection.

What that is may be discovered by asking whether it is really the case that all living creatures grow old and die. We know that an insect may live for days, another for weeks, another for months; that a fish may live for years, man for scores of years, and a Big Tree for centuries; but are there any creatures that need not die? It seems that natural death is more or less successfully evaded by most of the Protozoa, which, being unicellular or non-cellular, have no 'body' to keep up, which have very inexpensive modes of multiplication, which can continually recuperate their wear and tear. There is good reason to suspect that the same is true of multicellular animals like Hydra and Planarian worms.

The clearest statement of the problem has been given by Prof. C. M. Child in his *Senescence and Rejuvenescence.* The process of progressive differentiation or complexifying involves the accumulation of relatively inactive constituents in the living matter. It becomes necessary to have stable frameworks, and it is difficult to keep these young. The vital current deposits materials in its flow, and the bed begins to slow the stream. There are always processes of rejuvenescence at work, removing the relatively inactive material, and re-accelerating the rate so that fresh erosion occurs. All sorts of devices are resorted to, which secure rejuvenescence; many of them are very drastic, such as periodically breaking the body to bits and beginning afresh; but the tendency is for rejuvenescence to lag in the higher animals and for senescence to win. It cannot be otherwise. Death was the price paid for a body; senescence is the tax on specialisation. In the very simple organisms the stable mortal parts of the colloidal substratum, which is life's laboratory, can be reduced and restored piecemeal, and the creature never grows old. Perhaps the same is true of the fresh-water polyp, which thus will have, besides its indifference to wounds, another reason for being called Hydra. But as life became more worth living, and the organism more of an agent, the capacity for rejuvenescence was limited. Thus, as Professor Child tells us, "For his high degree of individuation man pays the penalty of individual death, and the conditions and processes in the human organism which lead to death in the end are the conditions and processes which make man what he is." Thus one may perhaps say without irreverence that science has made the shadow of death more intelligible.

What have we, then? At the foot of the scale there are some organisms in which rejuvenescence keeps pace with senescence, and natural death is evaded. At the top of the scale there is the senility of many men and of some domestic animals, like horses and dogs. It is certain that senility is not within the scheme of Animate Nature apart from Man. For many wild animals there is normal senescence, for many there is not even that. There is a slight lowering of vitality and a slight environmental buffet sends them off the stage. But why is it that the fish *Aphia pellucida* lives only for a year, dying off like an annual plant, while others live for many years? The probability is that the duration of life is limited to some extent by the constitution of the creature, but that within these limits it has been regulated in adaptation to the conditions of life, that it has been punctuated in reference to large issues, namely the welfare of the species. Not that there is any purposive adjustment, but simply that for each set of given conditions there is an effective age which becomes the age of the surviving types. It is not difficult to understand that a variation in the direction of longevity might be very unprofitable and would be certainly eliminated by the gradual disappearance, paradoxical as it may seem, of the long-lived type. For the longevity might mean that the organism continued multiplying when it was past its best and thus impaired the vigour of the stock. The longevity might mean that the organism continued multiplying after it had suffered so many dints from the years that it could no longer give the offspring a successful send-off in life. Such variations condemn themselves literally, and the length of life is by selection adaptively punctuated towards the welfare of the race. In some of the higher organisms prolonged multiplication is constitutionally prevented on the female side after a certain age is reached, and that is also adaptive. This idea must be gently transferred to human life. Apart from multiplication altogether, apart also from senility, which is often avoided with masterly success, it seems in Man's case very doubtful that it is for the good of the race that longevity should become too pronounced a habit. There is profound wisdom in Goethe's saying that Death is Nature's expert device for securing abundance of life.

§ 8. *Apparent Wastefulness.*

Another shadow is the apparent wastefulness. "So careful of the type she seems, so careless of the single life." The abundance of life has its correlate in the abundance of death. "What a book," Darwin wrote, a "a devil's chaplain might write on the clumsy, wasteful, blundering, low and horribly cruel works of nature!" (*More Letters,* Vol. I., p. 94, 1856). But we doubt whether he would have written this a quarter of a century afterwards, when his insight into the economy of Nature had grown clearer. We need not doubt, for in 1881 he wrote: "If we consider the whole universe, the mind refuses to look at it as the outcome of chance—that is, without design or purpose" (*More Letters,* Vol. I., p. 395, 1881).

Wastefulness is rather a question-begging epithet. The abundance of small fry has made the life of higher creatures possible. We do not say that the purpose of water-fleas is to feed fishes, any more than we say that the purpose of certain fishes is to feed man. What we say is that the extraordinarily prolific multiplication of humble organisms affords a stable foundation on which a higher life has been built. The number of free-swimming larvæ in the waters is beyond our powers of picturing, and we think too little of the wonder of this everyday multiplication which is so different from anything in the inorganic world. Only a fraction of these larvæ come to anything, but since they form the sustenance of finer expressions of life, we see no reason to speak of wastefulness. The scheme of Animate Nature is in part a cycle of incarnations; we may not approve of the scheme, but it is not a wasteful one. In this connection it may be observed that it is a misrepresentation to speak, as Professor Hobhouse does, of the result of evolution being that "Species should learn to destroy each other more efficiently", for this disguises two facts,—(1) that huge numbers of animals live on detritus, which is often produced by physical agencies; and (2) that what very frequently happens is the establishment of a *modus vivendi* which lives and lets live. But our general point is this, that a certain security as regards the means of subsistence is a condition of economising reproductivity in higher animals, which means the recognition and development of personality. Is wasteful the term to apply to the existence of that teeming organic proletariat which is one of the primary conditions of personalities?

The view that there is a deep incongruity between the facts of the case and the possibility of religious interpretation has been forcibly stated by Professor Lovejoy, who does not, however, accept the conclusion. "Darwinism or the doctrine of natural selection declares these three unlovely aspects of the world—its wastefulness, its disharmony, and its cruelty—to be not simply casual details of the picture, but the very essence of that whole evolutional process which, regarded in its results and not in its methods, had seemed so admirable and so edifying to contemplate" (Lovejoy, 1909, p. 93). Whether the seamy aspects of Nature which the theory of natural selection is supposed to bring into relief are really centrally significant and ubiquitous aspects, is, Professor Lovejoy admits, "a question which contemporary biology is diligently endeavouring to settle by its own proper methods. One can only say now that the dominant tendency is distinctly towards an answer in the negative" (1909, p. 95). We have tried to show that this dominant tendency is reasonable.

§ 9. *A Balanced View.*

These are not all the shadows by any means, but they must serve for illustration. In other studies we have seen that the struggle for existence is often an endeavour after well-being; not a miserable internecine squabble around the platter of subsistence, but including all the answers-back which able-bodied, able-minded creatures make to environing difficulties and limitations. We have seen that natural selection is neither altogether automatic nor in any case arbitrary, but is a discriminative sifting in relation to an established Systema Naturæ—a fact which helps to secure progressiveness. We have seen that variation is not haphazard nor fortuitous, and that heredity does not leave us stifling in a fatalistic atmosphere. We have seen that beauty is Nature's universal hall-mark on fully-formed, independent, healthy organisms, living in natural conditions. And lastly we have seen that many of the shadows become less perplexing when carefully scrutinised.

Our thesis is violently opposed to the view of some of the greatest thinkers. Aristotle, who knew Animate Nature with an intimacy insured by his genius and patience, spoke of the lack of order in Nature and likened it to what may be seen in the life of a slave, to whom, on account of his low estate, certain license is permitted. Hegel, to skip about two millennia, compared Nature to a Bacchantic dance. We regard both comparisons as infelicitous. Indeed, we are not in the least inclined to accept the depreciatory views of Animate Nature which have been put into circulation. Many are obvious libels. There is some truth in Aristotle's dignified caution that Nature is dæmonic rather than divine, —but we reject as ignorant and impious Luther's brusque saying: "The world is an odd fellow; may God soon make an end of it." Is it unreasonable to suggest that those who allow themselves to be oppressed by the discords and disharmonies in the world without are in part themselves to blame for the weight of their burden, by remaining, more or less consciously, under the domination of the geocentric, anthropocentric, and finalist pre-conceptions of the Middle Ages, which regarded Man as the hub of the Universe?

In reference to the misery of catastrophes, like the Calabrian earthquake or the "Titanic" wreck, we venture to note how the apologetic problem changes with our changing outlook on Nature. Not many generations ago these calamities were directly and literally referred to "the hand of God"; under the conception of the reign of law "such acts are now regarded as acts of divine permission rather than of commission". No 'sceptic' would write of them now as Voltaire did of the Lisbon earthquake. Moreover, every one feels that it is not an orderly Universe if the laws of the strength of materials or of oceanic currents can be abrogated by mercy for individual lives. Without accepting an exaggerated view of the Uniformity of Nature as absolute, we know that within certain temporal and spatial limits we can trust to the regularity of frequently observed sequences. It would be an intolerable world if there were loopholes for individuals even when the number of lives lost is tragic beyond any words. Many speak, rightly we believe, of the unity of 'purpose' working in Nature and its evolution, but do not the tragedies show us plainly that this word Purpose, though the best we have, must be used in this connection in a symbolic way, being Purpose with a plan larger than we can understand?

If our view of Animate Nature presented no difficulties, it would be justly regarded with suspicion. Truly, it presents difficulties. There is often lack of plasticity; there are imperfect adaptations; there are taxes on progress; there are many parasites; there is some suffering and many a domestic tragedy; there is the astonishing spectacle of the demolition of masterpieces that millions of years have gone to fashion; and there is often a note of wildness that startles us. No one can shut his eyes to the difficulties, our protest is against allowing them to blot out the sun. The plasticity, the adaptations, the progress, the inter-linkages, the joy, the happiness, the masterpieces, the note of gentleness, how they make the shadows shrink! Our thesis stands that the facts of an accurate Natural History are not incongruent with an interpretation of Nature in higher terms.

We have, moreover, to bear in mind that the evolution is still in progress, that organisms are still subduing the inorganic unto themselves, that the mind-body is still continuing its arduous task of subordinating the body-mind to its purpose, that we in facing and mastering difficulties are sharing in working out a better future for our successors. The ladder of evolution is often very steep and organisms may slip down into disintegrative phases, but the bigger fact is that the main trend of evolution is essentially integrative.

Who shall impiously prescribe its limits, especially in the Kingdom of Man, where Personality seems to be beginning to transcend Organism?

SUMMARY.

It is a defensible position that Animate Nature and its evolution are congruent with a spiritual or religious interpretation. A scientific view of the system of which we form a part cannot, indeed, prove anything about the value or significance of Nature, but it is not inconsistent with the idea that Nature may be a Divine creation. Perhaps this is even suggested by the beauty, the harmony, and the progressiveness of Animate Nature. But there are many shadows.

There is a notable lack of plasticity in highly adaptive organic structure, and if environmental conditions change, highly specialised types may perish because of their very perfection. Only in intelligent resourcefulness is there a way of escape. But every art is limited by its medium, and the extinction of types is often the nemesis of their long-continued stability. Moreover, the external vicissitudes have doubtless had a very important rôle in organic evolution. And even though lost races leave no direct descendants, some of their gains may be continued on collateral lines.

There are some cases where arrangements that are usually well-adapted are fatally inadequate in a crisis, as when the moth flies into the flame or the lemmings swim out into the sea. But adaptations must be, on the whole, in reference to normally recurrent routine, not in reference to very exceptional conditions; though as a matter of fact there are some adaptations which meet rare difficulties. Imperfection of adaptation is often illustrated when organisms are changing their habits or their habitat, and it would be a magical world if it were not so.

It is quite futile to try to make a cosmic shadow out of the frequency of disease. In natural conditions constitutional disease is unknown—if it arises it is not allowed to grip; and microbic disease —so common when Man interferes—is exceedingly rare in wild life.

Another shadow is the frequency of parasitism. Parasitic plants and animals are legion and almost no living creature escapes them. It is abhorrent that fine organisation should be spoilt, but many parasites do their wonted hosts very little harm. Many parasites are repulsive in form, colour, and movements—the brand of their degeneracy. The drifting life of ease seems inconsistent with Nature's way of putting a premium on strenuous endeavour. But parasitism is, to begin with, a response to environing difficulties and limitations, the parasite can have little awareness of the significance of its step; its host is in most cases simply a promiseful area of exploitation; the parasitism often fades into symbiosis and commensalism; it is often resorted to by the mothers seeking a safe place for the young; it sometimes has a useful eliminative influence. That there is sometimes a hint of devilry in parasitism must be admitted, but there is great risk of fallacious anthropomorphism here.

Another reproach hurled at Nature is that of cruelty, which may be discussed along with parasitism since it refers to the nutritive chains that bind organisms together. That many animals prey on others is obvious, and this must sometimes involve suffering. Yet little is known of their pain, and, apart from a few difficult cases, there is no torturing.

Another shadow is that of senescence and death. But senility at least is not a disharmony in the realm of organisms, only in mankind. Growing old is a necessary tax on differentiation, for as a stable framework grows in complexity processes of rejuvenescence are bound to lag. In some simple creatures natural death is successfully avoided. "The conditions and processes in the human organism which lead to death in the end are the conditions and processes which make man what he is."

Oppressive to many is the apparent wastefulness. But the abundant multiplication of humble organisms affords a stable foundation on which a higher life has been based, and a truly marvellous working equilibrium wrought out. The scheme of Animate Nature is in great part a cycle of incarnations; it may attract or repel us, but it is not wasteful.

That there are shadows is admitted, but it is significant that they tend to disappear in the light of increasing knowledge. They do not force us to conclude that there is any radical incongruity between a scientific description and a religious interpretation of Nature.

LECTURE XIX.

THE CONTROL OF LIFE: LESSONS OF EVOLUTION.

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§ 1. *The Idea of the Controllability of Life.* § 2. *Heredity the First Determinant of Life.* § 3. *Nurture the Second Determinant of Life.* § 4. *Selection the Third Determinant of Life.* § 5. *Importance of Correlating Organismal, Functional, and Environmental Betterment.* § 6. *Dangers of False Simplicity or Materialism.* § 7. *Science for Life.*

A STUDY of human history which yielded no practical counsel to mankind would be self-condemned, and the same must be true of a study of animate evolution. What are the lessons of evolution?

§ 1. *The Idea of the Controllability of Life.*

There is practical suggestiveness in the very idea of organic evolution. Darwin changed a relatively static conception of the Realm of Organisms into an intensely dynamic one. The forms of life which seemed so fixed were shown to be in racial flux—though the movement might be as imperceptible as a glacier's flow. What Man could do in a relatively short time by breeding from selected variants was shown by his success with domesticated animals and cultivated plants. Thus the whole aspect of things was changed. The outlook became kinetic, and this led on naturally to the practical idea of *the controllability of life.* If flowers and pigeons and the like can be controlled, and controlled so well, then why not human life also? If Man can evolve from out of a crab-apple all the treasures of the orchard, may he not replace sourness by sweetness in human character? If Man can evolve from out of a wolf-like creature the domesticated dog, the trusty guardian of his flocks, may he not hopefully try to evolve the wolfish out of mankind? A few Darwinians were indeed inclined to be too sanguine, overlooking the fact that all that Man did in his domestication and cultivation was to use with discretion the variational material which the organisms themselves put into his hands.

Moreover, investigation brought to light many instances of marked modifiability. So much can be done by training, by exercise, by dieting, by altering the surroundings that we cannot wonder that there was for a time an exaggeration of the transforming power of function and environment. The fact is, however, that what is expressed from within is much more important than what is impressed from without; the range of variability is much wider than that of modifiability. Moreover, we do not know that the individually acquired modifications of the parents can be entailed as such or in any representative degree on the offspring.

It was pre-eminently Pasteur who made the idea of controllability glow. He may be taken as type of the many illustrious investigators who have been inspired to great achievements by the idea of the biological control of life. Beginning with measures for getting rid of the silkworm disease, which was ruining the south of France, Pasteur proceeded to attack such terrible scourges as splenic fever and hydrophobia, and conquered by understanding them. With object-lessons on a grand scale he convinced every open mind that the days of folded hands and resignation were over, and that it was for Man, with Science as torch, and with Mercy in his heart, to enter courageously into the fuller possession of his Kingdom.

It was the beginning of a new era for mankind, and it influenced thought and feeling as well as practice. If there be almost no constitutional disease in wild nature, why should it persist in mankind? Why should Man and his stock have a monopoly of senility? If certain microbic diseases can be got rid of, why do we allow them to linger in our midst? And we have, of course, practically ousted some terrors from their lairs, as in the cases of smallpox and typhus. If we cannot alter the span of human life, we can at any rate make sure what we shall *not* die of. The practical corollary of the doctrine of evolution is the controllability of life.

We have argued that Nature is crowned in Man, not merely because he has an all-round excellence of differentiation and integration, but especially because he is the finest expression of those qualities which mark the main trend of organic evolution,—such as freedom, awareness, mastery. Speaking metaphorically, we may say that Nature finds herself in Man, who understands, appreciates, and enjoys her in a sense that is certainly not true of the grazing herd. But the anomaly is that Man, minister and interpreter of Nature as he is, is subject to inhibitions and disharmonies which are not tolerated in wild nature. If there be an underlying purpose or meaning in organic Evolution, is not Man hindering it by his slowness to understand and fall in with the principles of its accomplishment? If the central fact in evolution be "the slowly wrought-out dominance of mind in things", it is surely man's fundamental task to use this expanding mind to control his own life. If the process of Evolution suggests any lesson, it is surely that "the sharpened life commands its course",—by brains, correlation, organisation. At lower levels the organisation that succeeds may be reflex, tropistic, instinctive; for Man it must be intelligent, at least; rational, if possible. But what the evolution-process points to with firmness is that Brains pay—Brains that include Love as well as Logic.

§ 2. *Heredity the First Determinant of Life.*

The first determinant of life is the natural inheritance—the past living on in the present, often with something new superadded. Nothing seems further from the possibility of control than heredity: as the satirical poet observed, "a man cannot be too careful in the choice of his parents". But while we cannot choose our *parents,* we can, more or less, choose our *partners* in life, and this may mean controlling heredity. We cannot create a desirable variation by taking thought, but we may perhaps be able to prevent a very undesirable one from being continued. Parents have also some opportunity and responsibility in regard to the partners whom their children may choose. The days of coercion are over, but there is no coercion in the garrisoning (probably most effective when least direct) of the affections against the advances of the ignoble, the inefficient, and the hereditarily handicapped. This again means controlling heredity. The inheritance from the past is beyond control, except in so far as its expression may be influenced by nurture; but the inheritance handed on to the future is in some measure within control, since the mating of fittest with fittest, of fit with fitter, of fit with fit can be encouraged by common sense and good feeling, while the mating of fit and unfit, and of unfit with unfit can be discouraged. This has, of course, been done over and over again by peoples—such as the Hebrews—with pride of race and an enthusiasm for vigour. But now it can be done with fuller and finer knowledge. Certain it is that there can be no secure progress which does not recognise that Heredity, the past living on in the present, is the first Fate, and the greatest of the three. "Bless not thyself," said Sir Thomas Browne, "that thou wert born in Athens; but, among thy multiplied acknowledgments, lift up one hand to heaven that thou wert born of honest parents, that modesty, humanity, and veracity lay in the same egg, and came into the world with thee."

§ 3. *Nurture the Second Determinant of Life.*

The second determinant of life is Nurture—all manner of environing influences, whether due to surroundings, or to use and disuse, or to the social fabric. This nurture is largely within control—especially for the more prosperous, or more enlightened, or more idealistically ambitious members of the community; and the fullness of expression that the inheritance finds in development depends in part on the abundance and appropriateness of the nurture. If the nurture be opulent the buds may blossom richly. Conversely, buds which are detrimental may be kept dormant if the appropriate wakening stimulus be withheld; and for the individual at least this may be well. More than a few of us may have to confess with the poet that we are "stuccoed all over with quadrupeds", including some reptiles; but, happily, these may remain in a starved state if we refuse them the appropriate nurture. Thus "the ape and tiger" in Man may die,—in the individual at least. It comes to this, that the controllability of nurture gives us some hold on the expression of our inheritance. We cannot alter the number of talents that we get to start with, but we certainly have some freedom in our trading with them. Not very often can a man truthfully say that he was hereditarily compelled to put his inherited talent in a napkin and bury it in the ground.

As the result of well-chosen influences and strenuous discipline, an individual may acquire some desirable quality,—usually a nurtural modification of an inherent predisposition. Now, as we have seen, it seems unlikely that this sort of personal gain can as such get into the racial treasure-box. The possibility remains, however, of re-acquiring the gain in each successive generation; or, contrariwise, of saving a generation from a gratuitous loss. This is peculiarly important for Man, where the extra-organismal social heritage counts for so much in nurture, especially as regards the higher human qualities.

On another line of thought, it is doubtful whether those who are not accustomed to look at life biologically are quite aware of the value of variations. These new departures, idiosyncrasies, eccentricities, individualities, originalities are the most precious things in the world,—when they are on the upgrade. If we do not understand them we call their possessors cranks; if they are ahead of the race, yet appreciated, we speak of genius. In their finest human expression they mean reachings forwards to super-man. No one can offer a recipe for their production, but this practical point is clear, that, given a promiseful new departure, we may fail to make anything like the best of it if the nurture be not likewise evolving. Good nurture gives a progressive variation more chance of realisation, success, and transmission. It is a sad waste when a fascinating new plant is choked in a sluggard's garden. Nurture determines in part the sort of reception that a new variation meets with, and nurture consists in part of a subtle complex of liberating stimuli, which are to our potentialities as sunshine and rain to buds. "As is the world on the banks, so is the mind of man." "What we have inherited from our ancestors we must put to use, if it is to become our very own." When a belief in the transmission of individually acquired somatic modifications was general, reformers tended to exaggerate the directly ameliorative value of good nurture. Now that the belief in the transmission of individually acquired modifications has been badly shaken, many thinkers have swung to the opposite extreme, and the rôle of nurture is depreciated. But its individual importance remains, and its indirect importance also.

Prof. Karl Pearson and his collaborators have concluded that "the degree of dependence of the child on the characters of its parentage is ten times as intense as its degree of dependence on the character of its home or uprearing". "It is five to ten times as profitable for a child to be born of parents of sound physique and of brisk, orderly mentality, as for a child to be born and nurtured in a good physical environment." It may be doubted, however, whether it is possible to discriminate so precisely between what is due to hereditary nature and what is due to available nurture. It is also important to inquire when the nurture is supposed to begin: there is much nurture before birth.

Since hereditary nature and liberating nurture are both essential, there is no rigid antithesis. Nurture is important as a condition of normal development, and on the richness of its liberating stimuli the degree of development in part depends.

Gudernatsch has shown that in tadpoles fed on thyroid gland there is differentiation without growth, while in tadpoles fed on thymus and spleen there is growth without differentiation. A character *known to be* part of the inheritance may remain entirely unexpressed in the individual development because certain environmental conditions are lacking, yet the heritable character may be handed on all the same. Thus fruit-flies (Drosophila) of a Mendelian race with a peculiar abnormality may appear perfectly normal if raised in a dry environment, but the presence within them of the 'factor' for the abnormal feature may be demonstrated by rearing their offspring in a damp place. This shows the importance of nurture *for the individual.*

A diagrammatic illustration concerns the red Chinese primrose (*Primula sinensis rubra*). Reared at 15°—20° C. it has red flowers. Reared at 30°—35° C., with moisture and shade the same plants have pure white flowers like those of *Primula sinensis alba,* which always has white flowers. Thus we see that the development of colour in the red Chinese primrose depends on its nurture.

Take another illustration from the fruit-fly. There is a mutant stock that produces supernumerary legs, in considerable percentage in winter, few or none in summer. Miss Hoge finds that when the flies are kept in an ice-chest at a temperature of about 10° C., a high percentage of individuals with supernumerary legs occurs. In a hot climate there would be no evidence that the peculiarity was part of the inheritance; in a cold country it would be obvious. This shows that the expression of the inheritance as regards a particular character sometimes depends on nurture.

In estimating the importance of nurture for the individual man, we must remember how largely the human mind is a social product. As Prof. George H. Parker (1914) puts it, "Our intellectual outfit comes to us more in the nature of a social contribution than an organic one." Perhaps it is going too far to suggest that as regards our minds we are more 'made' than 'born'; but this is certain, that while our mental capacities are primarily determined by heredity, they can be encouraged and augmented, or inhibited and depressed, *within wide limits,* by nurture.

On no account are we to countenance, if we can help it, spoiling good stock by bad, for that is the worst thing man can do. But we must beware of confusing veneer with hereditary nature. We must not too readily assume that people are as good as they look, or as bad as they look. In regard to the last, in an interesting study entitled *Environment and Efficiency,* Miss Mary Horner Thomson tells of her investigation of 265 children, mostly of "the lowest class" (Class A, fourth below the poverty level!), who had been sent to institutions and trained. She found that 192 (72 per cent.) turned out well; that 44 (16 per cent.) were doubtful; and that only 29 (less than 11 per cent.) were unsatisfactory, and of these 13 were defective. These figures, which should of course be checked and extended, afford some evidence of the controllability of the individual life.

Less extremely than some other Mendelians, Professor Punnett writes: "Hygiene and education are influences which can in some measure check the operation of one factor and encourage the operation of another. But that they can add a factor for a good quality or take away a factor for an evil one is utterly opposed to all that is known of the facts of heredity."

But a practical note may be here permitted. It is very difficult for us to know all that is in a man's inheritance. Indeed we cannot, for we can see only what is expressed, and the condition of expression is appropriate nurture.

Therefore in Man's formative periods the common-sense view is surely this. We cannot be quite sure what we have in our inheritance, therefore let us give every chance to such qualities as are liberated by ameliorative nurture. We cannot be quite sure what may not be in our inheritance, therefore we take no chances; let us avoid the kind of nurture that arouses sleeping dogs. The theory of the control of life is here quite plain: the practice, we admit, is no easier than before, save that we understand the issues better.

§ 4. *Selection the Third Determinant of Life.*

The third determinant of life is Selection, and this is of peculiar importance in the human sphere, where Natural Selection is largely in abeyance and the sifting is in great part rational and social. We call it rational and social because it is more or less deliberate and thought-out and because it is effected by social sieves; unfortunately this does not mean that it may not be terribly mistaken. In early days mankind was much in the sieve of Natural Selection—the meshes being wild beasts, changes of climate, scarcity of food, unchecked disease, and so on, and we are the better for that sifting to-day. But, as every one knows, the whole trend of human evolution since civilisation began has been to throw off the yoke of natural selection. Some of its thraldom remains, as in cases of differential death-rate, where the inherently weaker succumb in larger numbers, but we are continually interfering—necessarily and rightly—with the sifting operations of disease, hard times, and the like. This interference has been in great part prompted by the strengthening and diffusion of the humaner sentiments and a realisation of our solidarity; but it involves, as every one recognises more or less clearly, the terrible danger of relaxed sifting. In regard to that the records of organic and social evolution are alike eloquent. No one has stated the dilemma more poignantly than Spencer: "Any arrangements which, in a considerable degree, prevent superiority from profiting by the rewards of superiority, or shield inferiority from the evils it entails—any arrangements which tend to make it as well to be inferior as to be superior, are arrangements diametrically opposed to the progress of organisation, and the reaching of a higher life." That way perdition lies. It is a dilemma of civilisation that we cannot tolerate Nature's régime, the individual life means so much to us; and yet we have not replaced it by any sufficiently strict, and consistent, and carefully thought-out sifting methods of our own.

There is satisfaction in healing the sick and preventing wastage of life; we cannot but try to alleviate suffering; but there is no gainsaying the danger of being cruel to future generations by being kind in the present. There is the undeniable risk of helping too much, of coddling the undesirable and unwholesome so that they get strength enough to multiply, often spoiling good stock with the infiltration of bad. The wheat may have too much sympathy for the tares, and societies for the amalgamation of heaven and hell do not commend themselves to the wise.

This is a large and difficult question—the transition from Natural Selection to some other kind of selection which will grip the germ-plasm. The following three considerations are submitted. (1) In a number of cases the diseases and miseries with which civilised man is successfully coping are *indiscriminate* in their elimination. They thin the ranks, but they do not weed out or sift. The checking of such diseases and miseries will not, therefore, especially encourage the survival of types who are a source of weakness to human society. Hygienic endeavours which interfere with indiscriminate elimination—as in the case of much infantile mortality—may be pushed on unhesitatingly.

(2) As things are, there ought to be no question of drastic social surgery or of accepting Plato's proposals for the purgation of the state. For, on the one hand, we do not know enough to go far with safety, and, on the other hand, we are forbidden by the social sentiment of the most moralised types. What can be done is to work back to the old and wholesome pride of race, and to work away from whatever tends to encourage the multiplication of the diseased and the unwholesome. For a long time to come reformers will have enough to do along negative lines,—in seeking to prevent the spoiling of good stock with bad. Much may also be achieved by educating public opinion, replacing baseless prejudices by convictions founded on facts. It is not in the 20th century too much to ask that the quaint lists of forbidden degrees which used to be prefixed to copies of the Scriptures should be replaced by sound eugenic information.

(3) The commonplace must be borne in mind that man is a social person, and that what is biologically commendable may be socially disruptive. Many of those who are seriously handicapped by inheritance, and who ought not to be encouraged to have offspring, are in other respects valuable citizens. Many of the weaklings whom the social surgeon threatens are strong in spirit. As poets and artists, reformers and preachers, many of the weaklings have been among the "makers and shakers" of the world.

A useful office is the careful criticism of all the methods of discriminate elimination—whether deliberate or not—that are at work in mankind. Some economists have wisely urged upon us the importance of criticism of consumption, for it is plain that in our expenditure we are willy-nilly selective. Thus a tradition of consistent expenditure along restricted materialistic lines must make for the elimination of artists, musicians, and similar types who are the salt of the earth. It condemns them to celibacy; it lets them slowly starve. Considerations of this sort may be exaggerated so as to make life a burden too heavy to be borne, but it is plain that a community which is spending solely on things that perish in the using cannot be on a sound line of evolution. All expenditure that consistently promotes unhealthy occupations rather than healthy ones, that helps to foster and multiply the feckless rather than controlled types, that makes for sweated labour and slums rather than for well-paid work and gardens, is necessarily anti-evolutionary. From founding celibate fellowships at colleges down to advertising for gardeners "without encumbrances", every form of selection that tends to prevent good types from duly contributing to the composition of succeeding generations is to be condemned in the court of applied biology, often called eugenics. That there may be a higher court of appeal is not denied.

An outstanding fact of Animate Evolution is, that new departures making for the welfare of the race become ingrained and entailed as part of the adaptive organisation of the creature. In the case of Man there has been a similar enregistration; it is idle to deny that there has been a hereditary organisation of kindliness, helpfulness, cheerfulness, and so on. But this hereditary organisation proceeds slowly, and so we must trust greatly to the extra-organismal heritage of traditions, conventions, ideals, and the like which works very potently both as a stimulating nurture, prompting us to seek after virtue and understanding, and also as a selective agency, leaving us behind if we fail too utterly of what society expects of its members.

In education—intellectual, physical, and moral—we do of course habitually seek to utilise nurture in the widest sense which includes the social heritage—as a means towards making the most of the individual development, and what, it may be asked, have we to offer in the way of new suggestion? Simply this, that we might to advantage be more scientific and less vague; that we should utilise with resoluteness and conviction the suggestions which expert science has to offer in regard to manifold problems in the control of life. We are convinced that many of the so-called "cosmic shadows", such as the wastefulness of Nature, are misunderstandings; we are convinced that many of the shadows of human life are gratuitous, that they would be scattered if we let in more of the light of science. Our forefathers had to deal with these shadows in an indirect way or not at all; often the only thing to do was to try to get moral discipline out of them. But now we have made great advances towards understanding many of the human shadows, and it is only inertia that keeps us from directly dispelling them. Much is being done every day, but much more requires to be done, and our point is that the first and foremost lesson of evolution is: Let in more light,—more scientific light. Another lesson, of course, is: Let in more Love.

We know that a normal development of the human organism—in mind and body—demands an appropriate nurture; and yet we are implicated in human environments which are not up to the normal standard. In these environments, which make us ashamed, good men and women do indeed live, but there are surely many of the dwellers in darkness who find the great task of happiness altogether too hard.

Similarly, in regard to functional fatigue, there is a very considerable body of experimental fact in regard to the profitable length of a school-lesson, the profitable length of a school-day, the profitable length of a working-day, but how slow we are to utilise expert advice. In regard to occupational fatigue it is well known that it is the last straw that breaks the camel's back, and that what gives a push towards the danger-zone is often the entirely remediable delay in procuring appetising food.

These are familiar instances which we use simply as diagrams of the sad fact that we have got so accustomed to folding the hands when we did not know what to do, that we continue our resigned acquiescence even when the path of effective action is clear.

Professor Ward has spoken warmly of what man may achieve by an increased control of life (*Realms of Ends*, p. 112). "What the schoolmaster, the physician, and the philanthropist effect for the amelioration of the masses needs no description. Here again we have definite direction overriding the random and untrained impulses of the natural man. While the progress already made in the physical and social ameloriation of human life is inestimable, it is as nothing compared with what is still possible. Nine-tenths of our physical ills are due to ignorance and perhaps a still greater proportion of our social evils are due to selfishness. Present scientific knowledge is adequate to remedy a very large proportion of the former, and the ordinary prudential maxims of utilitarian morality, if they were only observed as they might be, would go far towards extinguishing the latter: they would put an end to the worships of Venus, Bacchus, and Mammon, if even they did not establish peace and chain up the dogs of war for ever." This was 1907-1910.

In the cases where the issue is relatively clear we have of course made great progress. We think of malaria and Malta fever, of diphtheria and plague, and many other diseases now coming under control. Not many years ago a number of religious and worthy Boer farmers—unconsciously impious—refused to join with an effective Anti-Locust League which depended for success on concerted action; they gave for their reason that it was attempting to stay the hand of God. But already this sounds like ancient history. Not in regard to diseases and pests alone, but in regard to depressing environment, ugliness, and dirt; in regard to dangerous and deteriorative occupations; in regard to poverty and unemployment, and, in short, all manner of objective evils, we have a determination rapidly growing stronger in our midst to get at the facts, to understand the operative factors, and to put brains into the task of betterment. Knowledge is foresight, and foresight is power. Science is for the amelioration and control, as well as for the enlightenment of life. To have this conviction strongly is surely to show no profane depreciation of the things of the spirit which are beyond the scientific universe of discourse.

It is the complaint of most of us that scientific efforts for the alleviation of misery and the scattering of gratuitous shadows move so very slowly. On the other hand, there is some reason to be afraid of movements that make people more comfortable without making them more ambitious in the quest for the True, the Beautiful, and the Good; and of reforms which save guilty people from the consequences of sin, selfishness, and sloth.

§ 5. *Importance of Correlating Organismal, Functional, and Environmental Betterment.*

A consideration of organic evolution suggests that progressive change depends on the correlation of functional and environmental with organismal improvement. We see writ large the lesson that a promising organisation may undergo involution in conditions of ease and safety, that the parasite is branded by degeneration, that unused organs dwindle away. We have seen that the development of characters is in some measure dependent on nurture, that progressive variations are apt to be short-lived unless the environment be also progressive, that the sifting is always in relation to a definite here and now—namely, the surrounding web of life in which some of the great advances of the past are always in some measure systematised. What is true of organic progress is yet more abundantly true of human progress, physical and social, as well as organic: that there must be a correlation of three kinds of endeavour,—that which aims at the improvement of the organism or breed (Eugenics), that which concerns itself with the amelioration of the environment (Eutopias or Euthenics), and that which seeks to bring about the betterment of functions, especially occupations (Eutechnics). Different sides of progress appeal to different minds, and few of us can work effectively at more than one thing at a time, but perhaps we should give greater prominence than we do to the simple lesson of Evolution that lasting betterment must be realised in place and work as well as in people, in environment and function (including leisure-time activity) as well as in organism.

§ 6. *Dangers of False Simplicity or Materialism.*

When we turn to the consideration of practical problems, we reap the reward of the time devoted to the discussion of the essential characters of the living organism. The conclusion that the category 'Mechanism' requires in Animate Nature to be supplemented by the category 'Organism', warrants us in carefully scrutinising all proposals which are tarred with the mechanistic or materialistic brush. They are bound to be fallacious in their incompleteness and perhaps also in the clear-cut definiteness which makes false simplicity seductive.

The conclusion that, among the higher animals at least, we have certainly to do with mind-bodies or body-minds, with individualities having at least a rill of inner life, justifies us in looking with suspicion at projects which declare the uselessness of the soul. The "false simplicity" error of materialism may be repeated at a higher level in a biologism which leaves out mentality in its account and treatment of a dog, or in a theromorphism which treats men as "bipedal cattle"—often of considerable ferocity.

It is not merely a theoretical question of giving the most accurate description of a dog or a horse or a man, it is also a practical question of making the most and the best of the creature. And in this respect the conclusion of thoughtful experts is unanimous, that the truer conception is also that which works best.

There are many higher reasons (religious, ethical, artistic, and others) for taking a big view of Man, but what we have been concerned with in this course is to show that the crude view is bad science. When Prof. Jacques Loeb says, "We eat, drink, and reproduce, not because mankind has reached an agreement that this is desirable, but because, machine-like, we are compelled to do so", he does not make a good antithesis. It is a familiar fact that Man often inhibits these organised impulses, and does so in reference to ideals which mankind has built up in a manner almost as far from the average animal's ways as these are from a machine's. When Le Dantec says, "The fact of being conscious does not intervene in the slightest degree in directing vital movements", we think that he is departing from the first canon of scientific work—accuracy. Often in man's experience it is just the being conscious that makes all the difference.

It may be useful to give two or three examples to show that proposals fundamentally biological need not be narrow or materialistic. Many authorities on education have emphasised on various grounds the importance of Play, but discussion passed to a firmer basis after the important work of Groos on the play of animals, for he showed that play was no mere safety-valve for superabundant energy and spirits, no mere relaxation, no mere recapitulation, but that it was a joyous apprenticeship to the business of life, a time for replacing instinctive predispositions by learning from experience, a time of elbow-room for variations, a time for experimenting before criticisms prune, before casualties induce caution, and before hard work brings on "life-harming heaviness."

Or again, it may be well for us, on our own behalf and for our children, to ask whether we are making what we might of the well-springs of joy in the world; and whether we have begun to know what we ought to know regarding the Biology or Psycho-biology of Joy. Have we given attention, for instance, to the work of the famous physiologist of Petrograd, Prof. Ivan Petrovich Pavlov, who was the first to demonstrate the influence of the emotions on the health of the body? That a good circulation is associated with cheerfulness is a familiar fact,—and how this organic jauntiness sometimes jars on the tired and sorrowful! But there is the converse proposition that cheerfulness makes for health. It was said of old time: "he that is of a merry heart hath a continual feast", and "a merry heart is the life of the flesh". Now, what the researches of Pavlov, Cannon, Carlson, Crile, and others have done is to demonstrate experimentally that pleasant emotions favour the secretion of the digestive juices, the rhythmic movements of the food-canal, and the absorption of the aliment. Contrariwise, unpleasant emotional disturbance and worry of all sorts have been proved to have a retardative influence on the digestive processes. When the hungry man sees the well-laid table his mouth waters, but every one knows that a memory or an anticipation will also serve to move at least the first link in the digestive chain. "It is now well known," says Professor Dearborn, "that no sense-experience is too remote from the innervations of digestion to be taken into its associations, and serve as a stimulus of digestive movements and secretions." Emotion may influence the production of adrenalin by the core of the adrenal glands, and a slight increase in this potent substance constricts the smaller blood-vessels, raises the blood pressure, excites and freshens the muscles, increases the sugar content of the blood, and so on. From the non-mechanistic position which we have defended in these lectures, it is of great interest and importance that good news, psychical if anything is, may set in motion a series of physico-chemical and vital processes, complex beyond the ken of the wisest. And the cheerful man, who cultivates the habit of happiness, finding good reasons for rejoicing—in the sunshine and stars, in flowers and birds, in works of art and the faces of his friends—will have his 'joy-reward' or euphoria added unto him unless he is fool enough to pursue it. Our point is, that, open to at least a large number of our fellow-creatures, there are sights and sounds that make for joy and that increasingly, as some of the Psalmists were well aware, and that one of the obvious lessons of evolution—and of common sense—is that we should use these well-springs freely.

What is true in regard to digestion applies also to other functions. Wordsworth knew this when he spoke of his heart responding to the sight of the rainbow and the recollection of the daffodils by the lakeside. He may not have known much about the complex pathways of the pneumogastric, but he was sure about the influence of joy on the circulation. Professor Dearborn has worked at the factors altering blood-pressure and he makes the notable statement that in the "general stimulation of the essential circulation in all constructive parts of the body, such as the brain, the muscles, and the digestive organs, joy exerts one of its most conspicuous benefits, and one that no one can doubt or ignore".

There are facts which point to the conclusion that a gladsome mind may also increase the integrative function of the nervous system. It is an indubitable fact that a joy—say of maternity, or discovery, or artistic creation—may become an exhilaration and enthusiasm of thought and will; but the same is true of bodily welfare. Good tidings will invigorate the flagging energies of a band of explorers; an unexpected visit will change a wearied homesick child, as if by magic, into a dancing gladsome elf; a religious joy will make men and women transcend the ordinary limits of our frail humanity. How it comes about is not yet quite clear; but somehow the oil of joy, as the Scriptures call it, operates so as to make the limbs more supple and the face to shine. Emotion has its physical accompaniment in motions throughout the body, in changes in secretion and circulation, and also in some other way whereby influences from some emotional 'centre' such, perhaps, as the optic thalamus (the second great division of the brain) surge up into the cerebral cortex, the seat of the higher mental processes, where joy and activity may be correlated.

We have referred to recent work on the physiology of joy simply as an illustration of the way in which science may be utilised in the control of life—not merely as regards exercise, fresh air, diet, and so on, but in the subtler task of developing the personality on what one may call direct lines.

The danger ahead is well known, that, just as the direct pursuit of health is apt to engender hypochondria and valetudinarianism, and just as the direct pursuit of happiness is apt to defeat its own end, so the direct pursuit of joy for the sake of the 'joy-reward' may prove consummately futile. But it is possible to make a bogey of this risk. We are not made of such friable material.

Forced cheerfulness is, of course, a horror, but the persistent will to be glad, if worthily satisfied with some of the real joys of life, may soon become a habit that requires no artificial stimulation. A conventional approach to Nature and Art is often rewarded much beyond its deserts, and men who began by taking walks for duty's sake have often become genuine enthusiasts for the open country. The pursuit of joy may be futile and the faking of it an abomination, but there is nothing absurd or morbid, for instance, in humbly learning to know more about the endless things of beauty which are joys for ever. If we make sure of these, the euphoria will look after itself.

It is surely for the guidance of youth to recognise that at levels far below Man's there is an enhancing of physical fondness by æsthetic embroideries and emotional tenderness, and the sobering of all by a working together of mates in the discharge of parental duties.

It is surely for the guidance of all to realise the extent to which animal life rises above a struggle around the platter of subsistence, and illustrates the raw material, at least, of domestic virtues. We cannot believe that animals "think the ought", so that in the strict sense the ethical note is not sounded, but when we consider their expenditure of energy towards results that are other-regarding not self-regarding, we seem to hear an ethical undertone. In any case it is not from Natural History that we learn the "Might is Right" doctrine.

§ 7. *Science for Life.*

Let us sum up the general argument.

(1) There is no doubt whatever that many of the human shadows that blot out the sun and make our feet stumble are *gratuitous,* and may be got rid of whenever man pleases. That this condition, "whenever man pleases", is not easily fulfilled we are well aware. But there is no doubt that we can get rid of many social handicaps, and go on to higher adventures, discovering more and more of the goodness of God in the land of the living.

A hundred years ago people shuddered at the name 'Gaol-fever', a terrible pestilence, which attacked judge and jury, prisoner and onlooker at Old Bailey. We call it typhus-fever now, and it is rare in Britain, thanks to the enthusiasm of the early nineteenth-century hygienists. It is a dirt disease, it can be controlled by care and cleanliness. It is due to a microbe, not yet isolated, which is transferred from man to man by infected lice. As Sir Ray Lankester says, the Angel of Death they spoke of a hundred years ago is the clothes' louse, which can be readily exterminated by the use of benzine. We cannot but feel that it was almost contemptible to have submitted for centuries to a tyranny of dirt; but the point is that we are continuing to submit to similar things. We are slow to gird up our loins. We are slow to learn the lesson of the Control of Life.

(2) It has been said that there are two views of this world, that which regards it as a swamp to be crossed as quickly as possible, and that which regards it as a marsh to be drained. The view to which our study of Animate Nature points is emphatically the latter. Man must continue the struggle against inhibitants,—the campaign in which living creatures have been engaged for millions of years, the endeavour to bring the inorganic into the service of the organic, to bring the body-mind into subordination to the mind-body, to eliminate the disorderly, the inharmonious, the involutionary. For we adhere to the thesis that evolution is *on the whole* integrative, not disintegrative.

(3) To put the same thing in a third way, which is more generalised, we are in profound agreement with the view well expressed by a contemporary philosopher,—that it is Man's part to build up, as he is doing, a scientific systematisation of knowledge which will form the basis of an increasing control of life. The mundane goal of the evolutionary movement is "the mastery by the human mind of the

conditions, internal as well as external, of its life and growth. The primitive intelligence is useful to the organism as a more elastic method of adjusting itself to its environment. As the mental powers develop, the tables are turned, and the mind adjusts its environment to its own needs. "*Mihi res non me rebus subjungere conor*" is the motto that it takes for its own. With the mastery of external nature, applied science has made us all familiar. But the last enemy that man shall overcome is himself. The internal conditions of life, the physiological basis of mental activity, the sociological laws that operate for the most part unconsciously, are parts of the 'environment' which the self-conscious intelligence has to master, and it is on this mastery that the *regnum hominis* will rest" (Hobhouse, 1915, p. 443). Of a truth, Science is for Life, not Life for Science.

SUMMARY.

The theoretical doctrine of evolution has for its practical corollary the fact of the controllability of life. Darwin was logically followed by Pasteur.

If the central fact in evolution be "the slowly wrought-out dominance of mind in things", it is surely man's fundamental task to use this expanding mind for the fuller possession of his kingdom, and the better ordering of his life in it. If evolution suggests any lesson it is this. We must inquire, therefore, into the determinants of life.

The first determinant of life is heredity—our relation to preceding generations—which includes not only the past living on in the present, but new departures or variations. We cannot alter our own inheritance, though it is ours to trade with, but we have some measure of control over the inheritance of future generations.

The second determinant of life is nurture—all manner of formative influences from surroundings and from use and disuse—and this is largely controllable in our hands. Nurture determines the fulness of expression that hereditary characters may attain in

development; it may re-impress desirable modifications on successive generations; it determines in part the sort of reception a new variation meets with. In mankind 'nurture' includes the 'social heritage'.

The third determinant of life is selection, and this is of peculiar importance in mankind, where natural sifting is largely in abeyance, where the sifting is in great part deliberate, rational, social. The relaxation of natural selection is the inevitable result of the increase of solidarity and sympathy; the difficulty is to find a sufficiently stern substitute. It should be noted that humane interference with indiscriminate elimination (which thins without sifting) cannot harm the race; that drastic social surgery is impossible in the present state of science and social sentiment; and that proposals which are sound biologically may be disruptive socially.

A study of animate evolution points to the conclusion that secure progress implies a correlation of organismal, functional, and environmental improvements. This is even more true as regards progress in the kingdom of man.

The hard-won conclusions that in Animate Nature the category 'mechanism' requires to be supplemented by the category 'organism', and that among the higher animals at least this requires to be supplemented by the conception of 'mind-body' (and in mankind by that of social personality), afford a test for practical projects. The error of materialism (namely, false simplicity) is often repeated at a higher level in biologism and theromorphism. The error is not in theory only, but shows itself in practice when the problem is to get the most or the best out of the creature.

It is very interesting to consider the extent to which animal life rises beyond a struggle around the platter of subsistence, and illustrates the raw material, at least, of domestic and social virtues. In the strict sense it may be true that the ethical note is not sounded, but there is often an ethical undertone. Nature has stamped this with her approval, Huxley notwithstanding.

LECTURE XX.

VIS MEDICATRIX NATURÆ.

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§ 1. *Biological Aspects of the Healing Power of Nature.* § 2. *Psychological Aspects of the Healing Power of Nature.* § 3. *Correspondence in Animate Nature to our Ideals of the True, the Beautiful, and the Good.* § 4. *Humanist Value of the Study of Animate Evolution.* § 5. *Scientific Description of Animate Nature Not Inconsistent with Religious Interpretation.*

§ 1. *Biological Aspects of the Healing Power of Nature.*

In many different ways Man has realised the healing power of Nature—*vis medicatrix Naturæ*—and all of them are instructive. One might refer, for instance, to the healing virtues in many natural substances, both animal and vegetable, some of which are extraordinarily quaint. It has been re-discovered in modern times that more than one snake carries in its gall-bladder a sure antidote to its own venom. Is not the old advice that the coward should eat of the heart of a lion, so that he might be brave, echoed in the modern treatment of a cretinoid child with the thyroid gland of a sheep? Is it not like a leaf out of an old book of magic to read that an enlightened use of pituitary extract enabled a successful examinee to add in a short time to his height the couple of inches that were required in order to secure a post for which he had proved himself otherwise eligible? It looks as if by taking sufficient thought one might be able to add a cubit to one's stature.

Interesting too is the reparatory power exhibited by many living creatures. One of the Big Trees or Sequoias which was a seedling in 271 B.C., suffered a burn three feet wide when it was 516 years old, and spent 105 years in folding its living tissues over the wound. When it was killed at the age of 2,171 years, a Methuselah among trees, it was engaged in healing a third great wound 18 feet wide and about 30 feet high. *Vis medicatrix Naturæ.*

A sponge can be cut up and planted out like a piece of potato-tuber; it may be minced and pressed through a cloth sieve without losing its power of regrowth. An earthworm thinks nothing of regrowing a new head or a new tail, or a snail its horn and the eye at the tip, even unto forty times. And this regenerative capacity is in the main adaptive in its distribution, for, as Lessona and Weismann have shown, it tends to occur in those animals and in those parts of animals which are in the natural conditions of their life peculiarly liable to non-fatal injury. Long-legged and lanky animals like crabs and starfishes usually show much of it; a self-contained globular animal like a sea-urchin shows little. The chameleon is one of the few lizards that does not regrow a lost tail, for, as it keeps it safely coiled around the branch, the regenerative capacity has fallen into abeyance.

Many other instances might be given of Nature's healing power:—the processes of rejuvenescence which in many organisms are continually at work in staving off senescence; the natural defences of organisms, such as the bodyguard of migratory phagocytes which deal with intruding microbes, and the mysterious intrinsic counter-actives or anti-bodies which deal with toxins; the immunity which some animals have to poisons, as the mongoose to snake-bite; the regulatory processes which sometimes occur when development or normal function is disturbed; the absence of disease and senility in wild life; the way in which some simple animals evade natural death altogether; the numberless arrangements for keeping the earth clean and sweet; the hygienic value of sunshine and fresh air.

These matters lie outside our proper theme, but they are well worthy of being recalled. Even when one is able to give a reasonable account of how they have come to be, they illustrate the balance and adaptiveness which is characteristic of Animate Nature. Only a system with order and progress in the heart of it could elaborate itself so perfectly and so intricately. There is assuredly much to incline us to "assert Eternal Providence, and justify the ways of God to Men".

§ 2. *Psychological Aspects of the Healing Power of Nature.*

Let us think, however, of the way in which Nature contributes to the hygiene and healing of our minds, so apt to be disturbed by the rush and racket of civilisation. There are deeply-rooted, old-established, far-reaching relations between Man and Nature which cannot be ignored without loss. Man was cradled and brought up in touch with Nature, and he must ever return to her, like the wandering birds whose life is never full until, moved by an organic homesickness, they come back to nest in the place where they were born. In a period of evolution which has been mainly urban, we miss our contact with the open country, which is, for many, a condition of full sanity, and makes for the steadying and enrichment of life.

Especially in youth is touch with Nature invaluable, for it remains true of the child who goes forth every day that "what he sees becomes part of him for a day, or for a year, or for stretching cycles of years". It seems a pity that the modern child is often unfamiliar with the Scriptures;

it is also to be deplored that he is often equally unfamiliar with the book of Nature.

Man needs to sojourn with Nature in order to get certain fundamental impressions without which he is impoverished, —the impressions from the starry sky, the pathless sea, the mountain-top, the dense forest, the apple-blossom, the ant-hill, the swallows flying south in autumn. Man cannot safely dispense with the fundamental impressions of power, of largeness, of pervading order, of omnipresent beauty, of universal flux, of intricacy, of growth, of the web of life, of adaptiveness, of evolution. Some minds weary of theories; let them by sympathetic observation hug the facts close, for thus also may deeper visions of reality be gained. Let them by observation draw water from what an expert naturalist has called "the bottomless well of surprises" (Chalmers Mitchell, *Finite Life and Individuality,* p. 60).

Another healing virtue in Nature is to be found in its perennial problem-setting interest. It arouses our attention; it intrigues the curious spirit; it leads us on and on like the tales of the *Thousand and One Nights.* As some one said, it is like a serial story. Its study is a brain-stretching exercise, and while it rewards the discoverer with both light and power, it subjects him to a discipline which engenders humility. For is not all our science rounded with mystery —mystery as to essences, mystery as to origins, mystery as to mutations. What we are surest of is the fundamental mysteriousness of Nature.

§ 3. *Correspondence in Animate Nature to our Ideals of the True, the Beautiful, and the Good.*

There is a legitimate scientific sense in which it may be said that Man is not only a part, but a product of the system of things and creatures that we call Nature. We know, indeed, that the system in its subjective expression is of Man's making; we know also that Man was made by the system. This is a familiar riddle. Needless to say, however, the system cannot mean to us a mindless kaleidoscope, for by no jugglery can one evolve mind out of anything else. But keeping to the common-sense view that Man is of a piece with a real external Nature, though transcending it when he will, we are concerned to point out that Nature is not altogether so foreign to Man as is continually insinuated.

The highest values for Man are the True, the Beautiful, and the Good; and it is of interest that there are in Nature features which do in some degree correspond to these. For it is not far-fetched to recognise that there is a rationality in Nature which is there to be discovered or discerned, which is not simply imposed upon Nature by our formulation. In what sense can we speak of a rationality in Nature? We mean that the system of things is more or less intelligible and explicable, that its relative uniformities can be trusted to, that when we get a grip of things we can make a coherent scientific system of them, which fits in with other parts of our intellectual systematisation. The formulation is sometimes premature and forced, but this is discovered in time, for Nature does not humour the inquirer. The Ptolemaic system in astronomy had to yield to the Copernican, that to the Keplerian, that to the Newtonian, and so on, but each advance meant getting nearer the truth, as we know by the increase in consistency on the one hand, and by the increase in the astronomer's power of prediction on the other. This would not be possible did not scientific formulation approximate towards a description of what actually happens.

That Nature is amenable to scientific formulation—discerned rather than imposed upon it—is admitted by all, but the interpretation is as difficult as the fact is obvious. It is a philosophical problem, but a scientific note may be permitted. To be asked how the marvellous fabric of science, one of the greatest human achievements, is to be explained in terms of evolutionary formulæ, is like being asked to account for the evolution of some very complex and relatively perfect structure like the human eye. Such questions have to be treated historically. Science and the eye must be looked at as the results of long processes of evolution, vastly older than Man. We trace the eye back to simple clusters of sensory cells, and we trace science back to simple practical lore, and further back still to pre-human capacities of learning. The acquisition and the expansion of the early lore had assuredly survival value; inborn curiosity has been from first to last a stimulus to inquiry; registration of gains in language and records, in instruments and permanent products, has made compound-interest advance possible. The result is not less admirable because its early stages were humble; but to ignore the early stages is to make the Ascent of Man magical.

But this does no more than give setting to the metaphysical problem. The strands of naturally-determined sequence have woven themselves into an intelligible pattern which science discerns; is it conceivable that they might have tied themselves into a knot baffling all disentanglement? And we must remember that almost all the discernment of the order of Nature has depended on seeing the stars in unbeclouded skies. Various attempts, such as Lachelier's (1871), have been made to explain the 'correspondence' between the intrinsic order of Nature and Man's capacity for deciphering it, but it seems doubtful if we get beyond some device which dissolves rather than solves the problem. It looks like a frontier-problem for Man's intellect.

But, leaving this puzzle, do we not find some quiet for our unrest in the progressive disclosure of the orderliness of Nature? Ours is no phantasmagoria of a world, but a Systema Naturæ. We are parts of a reasonable world, which voices reason and listens to reason. Its process has worked persistently towards masterpieces, of which the climax is the reasonable soul. From the intrinsic order and intelligibility of Nature, which the rise of the magnificent scientific edifice proves, we may not be logically permitted to make a transcendent inference to an Omniscient Creator, but it is in that way the heart of Man points. Our belief is that the Logos is at the core of our system, implicit in the nebula, as now in the dew-drop. It slept for the most part through the evolution of plants and coral-like animals, whose dream-smiles are a joy for ever. It slept as the child sleeps before birth. It became more and more awake among higher animals,—feeling and knowing and willing. It became articulate in self-conscious Man,—and not least in his science.

Scientific re-constructions are not arbitrary projections, for they work. In this sense there is rationality in Nature. But if there is rationality in Nature, must we not go further? For, as Aliotta has put it, "He who believes in the objective value of his science must then also believe in God. If an absolute thought does not exist, Nature cannot be rational". Descartes rested his belief in Science on his belief in God. In his Gifford Lectures Mr. Arthur Balfour rested the belief in God on a belief in science, for "God is himself the condition of scientific knowledge".

To some it may seem far-fetched to find in Animate Nature a correspondence to Man's truth-seeking. But we would point out, (1) that knowing is on the way to truth, and the knowing creatures, that face the facts, survive; and (2) that truth-seeking expresses the natural activity of the healthy mind, and Nature is all for health.

But it is also part of the deepest life of Man to enjoy what is beautiful, and one of the glories of the universe is its beauty. There is no place where this voice is not heard unless Man has obtruded noisily. Æsthetic emotion thrills what is best and highest in us, and it also makes the protoplasmic stream sing as it flows. The correspondence is never disappointing; and those who ask most are best satisfied. Part of the sensory delight that we have in beautiful sights in Nature may be due to Man's familiarity with them for so many hundreds of thousands of years; but this will not explain the correspondence that there is between the beauty of Nature and the ever-changing requirements of what we may call the 'spiritual eye'. In the contemplation of the supremely beautiful there is something of the satisfaction which religious feeling finds in music—a language expressing the inexpressible.

The system to which we belong is more or less intelligible, we can make good sense of it; it is beautiful through and through; but in what possible sense can it be said that there is in it anything corresponding to what we call good? If we patiently consider this question, two sets of facts present themselves. In the first place, Man began with strands of personality of pre-human origin, and some of these must have been very fine and others very coarse. We are apt to think oftener of the latter, for it is sometimes to our dismay and perplexity that they show themselves in the fabric of our life.

But do we think enough of the other side, that there must have gone to the making of Mankind some very fine pre-human materials—kin-sympathy, parental affection, the love of mates, some power of control and of endurance, some grit, and some gentleness. There are some springs of conduct in us that were flowing long before our race began, and while the water of some is bitter, that of others is sweet.

The second consideration is that a study of the evolution-process discloses a multitude of cases in which the reward of success is given to types which are careful parents, devoted mates, friendly kinsfolk. There is abundance of elbowing and jostling, but many who have consulted Nature have turned away before she has finished speaking. We do not say that the extraordinarily laborious insect-mothers are ethical agents; that would be a confusion of thought; we say, however, that the objectively altruistic type succeeds. Nature stamps not only the beautiful, but the other-regarding with the only approval which is hers to bestow—success in surviving. And, unless they are uncommonly good hypocrites, many of Life's children behave as if they found living good.

Thus Nature speaks to our moral as well as to our intellectual ear. Singling and sifting never cease, but Nature has certainly another counsel besides whetting teeth and sharpening claws. The limitations and difficulties which enforce struggle and competition are often effectively transcended by increasing parental care and sociality. Nature is continually taking advantage of her children's capacity for self-forgetfulness. In many races of animals success has been the reward of subordinating individual interests to those of the species. As a matter of fact, an extraordinarily large part of the energy of organisms is spent not on themselves, but for others. Nature, we think, stamps not only the beautiful but the good with her approval; and when we carefully consider the process of Natural Selection itself, do we not get from it a deep and ancient ethical message—that the individual must be content to subordinate himself to the species, even to lose himself in its progressive life? There is an ethical undertone.

§ 4. *Humanist Value of the Study of Animate Evolution.*

Nature's music does not cease on a merry chord, but perhaps it has a healing power. There is at all events, a tonic virtue in contemplating the evolutionary process of which mankind is an outcome. It is not a small thing, forsooth, that we are part and parcel of an Order of Nature which has evolved for millions of years like a long-drawn-out drama to finer and finer issues; that the process of evolution has in the main "the unity of an onward advancing melody"; that all through the ages, apart from blind alleys, life has been slowly creeping—and sometimes quickly leaping—upwards; that while there have been many mysterious losses even of branches from the great arbor vitæ, the flowers have become consistently finer. There was a time when there were no backboned animals; then fishes appeared, then amphibians, then reptiles, then birds and mammals, and then, after various tentatives, mankind—each age transcending its predecessor.

As we look back, then, on the world-becoming, we see that finer and finer actors have appeared from epoch to epoch on the crowded stage, and the situations have become more and more intricate. A great web has been passing for incomputable ages from the loom of time—hunger and love its warp and woof—but the pattern has become more and more subtle, and it sometimes seems as if it were picturing a story. Is there not meaning in the long-drawn-out but indubitably progressive evolution of the nervous system, in the increasing elaboration of behaviour, in the gradual emancipation of the psyche? The bird is more of an agent than the worm—more of a free agent; and the world has greater value to the bird than to the worm. Some simple creatures have only one answer to every question; but how complex is the life of the ant on the instinctive line of evolution, and of the dog on the intelligent line. Since the beginning of life there has been a growing appreciation and mastery of the world. Is it going to stop?

Perhaps no one has yet fully appreciated what may be called the principle of conservation in evolution. In a very literal sense, the higher animals are heirs of all the ages. Let us explain. Organisms have evolved by a trial-and-error method; they experiment organically, instinctively, and intelligently; above all, perhaps, in the mysterious antenatal life of the germ-cells they experiment in self-expression—just as water vapour does in snowflakes, but far more subtly. What are called variations and mutations in biological language are the organism's experiments in self-expression, and these are the raw materials of progress.

But, while the organism is ever making tentative suggestions and searching its environment with its tendrils, it is also remarkably conservative. It proves all things, but the other side is, that it holds fast that which is good. Great gains once made are not held lightly. Species become extinct and races perish, but important organic inventions are carried on by some collateral lineage. It was probably some ribbon-worm that first manufactured hæmoglobin—the all-important, oxygen-capturing red pigment of the blood. Many backboneless animals of higher degree on different lines of evolution have not got it, but the invention was too good to lose; and every one knows that all backboned animals from fishes onwards have red blood. Or again, the most primitive and in a way most puzzling kind of locomotion is that of the amœba flowing along, or rolling along—like a microscopic 'tank'—in the pond. Is it not a most suggestive fact that our health from day to day, and the development of our nervous system, are absolutely dependent on this self-same amœboid movement? Our white blood-corpuscles are amœboid cells; the outgrowth of nerve-fibres in development is in some measure due to amœboid movement. How far this evolutionary conservation of values goes, who shall say? In any case there seems good reason for regarding evolution as essentially integrative. By this we mean that it makes for co-ordination, consistency, harmony in the continual self-realisation of multitudinous forms of being. Ugliness, evil, inconsistency are disintegrative lapses that perish; beauty, goodness, truth—even in little bits—are integrative qualities that last. In any case, the big fact is, that men, bent on making much of their life, have behind them an organic momentum which is in part in line with what the best in us regards as best.

Purpose and promise. When we consider the grandeur of the long-drawn-out Evolution process and the wonder of its masterpieces, and especially when we realise its general progressiveness and its conservation of great gains, two ideas rise in the mind—purpose and promise.

It is difficult to shut out the impression that Nature is Nature for a purpose. We do not think any longer of a 'directive power' outside of the evolving organisms, but of a directive power which is bone of their bone and flesh of their flesh,—a directive power analogous to that which we ourselves know when we command our course or send an arrow to its mark. What we must particularly take account of is the main trend in evolution, making persistently for the dominance of mentality and the establishment eventually of personality. Whether what we now experience be the goal or near the goal, it gives significance to the whole long journey. And if Man be the highest product of evolution, and if the central reality in our life is our clear purpose, may we not ask whether there is not also a purpose at the core of the world-process? Von Baer, the founder of embryology, remarks that the naturalist is not precluded from asking "whether the *totality* of details leads him to a general and final basis of intentional design", and our foregoing discussions have led us to the conclusion that a scientific description of Nature is not inconsistent with a philosophical or religious interpretation in terms of purpose which manifests itself in the order of Nature, in keeping Nature in lasting remembrance. We must, however, recognise that just as Man's conceived purpose transcends the mammal's perceived purpose, as that in turn transcends the lower animal's ingrained or organised purposiveness, so, but much more, will the Divine Purpose transcend our highest thoughts of it. But we deem that if we err in using the word Purpose—the biggest word we have—we err less grievously than if we used no word at all.

Promise. For millions and millions of years there was throughout Nature no voice of life at all—nothing to break the silence but the thunder and the cataract, the waves on the shore, and the wind among the trees. The morning stars sang together and the little hills clapped their hands, but there was no voice of life at all. The long lasting silence was first broken by insects, but they never got beyond instrumental music. It is to the progressive Amphibians of the Carboniferous Age that we must look back with special gratefulness, for they were the first to get vocal cords, and, interestingly enough, a movable tongue. With them Animate Nature found a voice.

In a much deeper sense, however, we may say that for millions and millions of years Nature was speechless—never more than groaning and whispering, as it were. It was in Man that Nature became definitely articulate; that the inherent rationality was echoed. In poem and painting Man expresses his æsthetic appreciation and partial understanding of the system of which he forms a part; in his science he turns darkness into light; in the application of science he conquers and controls the world.

Every one recognises as a big fact of animate evolution the growing differentiation and integration (*i.e.,* organisation) of living creatures, but another side to it is the progressive external registration. There has been woven a web of life whose pattern has become more and more intricate, as for instance in the inter-relations between flowers and flower-visiting insects. This complexifying of inter-relations has been of great importance in evolution, for it is in reference to this external system that experiments are tested or even made, and that selection works. Thus, as it seems to us, the intensification of life has been in part secured and in part prompted by the growing complexity of the external Systema Naturæ. Thus living creatures contribute to the evolution of their kind not only directly by exhibiting variations and by personally testing these, but also indirectly by making new patterns in the web of life. If this be so, there is for Man the hint—the Open Secret—that progressive evolution depends not merely on the improvement of the natural inheritance, and on the intensification of the individual life, but also on the ennoblement of the external heritage—so much his own creation—the treasures of literature and art, the beautified region and city, the tradition of high ideals, and the multitudinous linkages—many in sad need of amelioration—in the framework of society itself.

In this mood we recall Emerson's famous passage: "So shall we come to look at the world with new eyes. Nature is not fixed . . . Spirit alters, moulds, makes it. Build, therefore, your own world.

"When a faithful thinker, resolute to detach every object from personal relations, and see it in the light of thought shall, at the same time, kindle science with the fire of the holiest affections, then will God go forth anew into the creation."

"As fast as you conform your life to the pure idea in your mind, that will unfold its great proportions. A corresponding revolution in things will attend the influx of the spirit. So fast will disagreeable appearances, swine, spiders, snakes [of course these words are used metaphorically, not zoologically], madhouses, prisons, enemies, vanish. They are temporary and shall be no more seen. The sordor and filths of nature, the sun shall dry up, and the wind exhale. As when the summer comes from the south, the snow-banks melt, and the face of the earth becomes green before it, so shall the advancing spirit create its ornaments along its path, and carry with it the beauty it visits, and the song which enchants it; it shall draw beautiful faces, warm hearts, wise discourse, and heroic acts, around its way until evil is no more seen. The Kingdom of man over nature, which cometh not with observation—a dominion such as now is beyond his dream of God—he shall enter without more wonder than the blind man feels who is gradually restored to perfect sight."

Putting what we have said in a different way, we may speak of the three voices of Nature, meaning the impulses that come from the threefold—practical, emotional, and intellectual—relation between Man and Nature. These are the wordless voices referred to in the XIXth Psalm: "Day unto day is welling forth speech, and night unto night is breathing out knowledge; there *is* no speech, and there *are* no words; their voice has no audible sound; yet it resonates over all the earth." The three voices are: Endeavour, Enjoy, Enquire. The first voice is Endeavour. What would our hereditary character be without Nature's millennial sifting of the insurgent, the adventurous, the controlled, the far-sighted, the strenuous? And the discipline is still binding. There is no doubt as to Nature's condemnation of the unlit lamp and the ungirt loin. One of the obvious lessons of evolution is the danger of having things made too easy!

The second voice is Enjoy. As we come to know Nature, we find that everything is wonderful. "You of any well that springs may unfold the heaven of things." "It is enough if through Thy grace I've found naught common on Thy Earth. Take not that vision from my ken." As we begin to feel more at home our wonder grows into what may almost be called affection. This is true of those who have what Meredith called "love exceeding a simple love of the things that glide in grasses and rubble of woody wreck". Science never destroys wonder or delight, but only shifts it higher or deeper. As Coleridge said, "All knowledge begins and ends with wonder, but the first wonder is the child of ignorance, while the second is the parent of adoration." We need to listen to this second voice which says Wonder, Enjoy, Revere. It was one whose life was far from being all roses who said:

> To make this Earth our hermitage,
> A cheerful and a changeful page
> God's bright and intricate device
> Of days and seasons doth suffice.

The third voice is Enquire: From the first Nature has been setting Man problems, leading him gradually on from the practical to the more abstract. Lafcadio Hearn tells us that in the house of any old Japanese family, the guest is likely to be shown some of the heirlooms. "A pretty little box, perhaps, will be set before you. Opening it you will see only a beautiful silk bag, closed with a silk running-cord decked with tiny tassels. . . . You open the bag and see within it another bag of a different quality of silk, but very fine. Open that, and lo! a third, which contains a fourth, which contains a fifth, which contains a sixth, which contains a seventh bag, which contains the strongest, roughest, hardest vessel of Chinese clay that you ever beheld; yet it is not only curious but precious; it may be more than a thousand years old." Indeed it is more than clay, there is an idea in it.

Natural Science has to do with a similar process of unwrapping—it opens the beautiful box, it removes one silken envelope after another, trying at the same time to unravel the pattern and count the threads—and what is finally revealed is something very old and wonderful—the stuff out of which worlds have been spun—"a handful of dust which God enchants". For we must see the scientific Common Denominator in the light of the philosophic Greatest Common Measure.

Varying the metaphor, one of the foremost investigators, Sir J. J. Thomson, writes: "As we conquer peak after peak we see in front of us regions full of interest and beauty, but we do not see our goal, we do not see the horizon; in the distance tower still higher peaks, which will yield to those who ascend them still wider prospects, and deepen the feeling, the truth of which is emphasised by every advance in science, that 'Great are the Works of the Lord.'"

These are the three voices of Nature. She joins hands with us; and says *Struggle, Endeavour.* She comes close to us, we hear her heart beating; she says *Wonder, Enjoy, Revere.* She whispers secrets to us, we cannot always catch her words; she says *Search, Enquire.* These three voices appeal to Hand and Heart and Head, to the trinity of our being. In listening to them we may be disciplined to hear even more august voices. Man's struggles for food and foothold have often helped him to much higher reaches of endeavour; to be thrilled with beauty may be a step to loving goodness; to try to find out scientifically what is true in Nature may be the beginning of waiting patiently upon the Lord. But our point is that to listen to the three voices of Nature is in itself worth while. It is a necessary and natural discipline of the developing human spirit.

We are familiar with the story of a rugged and very human Hebrew prophet, who after severe discipline climbed a mountain and heard the three voices of Nature. First, there was a great and strong wind,—a symbol of the practical voice, surely, which commands man to build his house upon a rock and to struggle against the storm, which teaches the sailor to trim his sails and the husbandman to prepare for the rain. Second, there was an earthquake,—a symbol of the emotional voice, surely, for is there anything so awful that stirs man and beast more deeply, that moves us down to the primeval bed-rock of human nature laid down in the time of the cave-dwellers. Third, there was the fire,—a symbol of the scientific voice, surely, for the fire of science burns up rubbish, melts out the gold, reduces things to a common denominator, and gives light to Man. Now it seemed to the prophet that God was not in the wind, nor in the earthquake, nor in the fire, and it seems strictly correct to say that listening to the three voices of Nature is not in itself religious. But it is a good thing to listen, and it may form a preparation for religion. It was so in the prophet's case, for after the echoes of the wind and the earthquake and the fire had died away, he heard a still, small voice—God's voice—a sound of gentle stillness, the Margin says—which spoke very incisively to him. It was a great experience to the prophet to have heard the three voices of Nature, but it meant more for him practically to hear the still small voice. And it may be that in *obeying* it he understood afterwards that God *was* in the other voices too.

So when we pass from the cold evening-light of science, which the schoolmen called *cognitio vespertina*, to the morning-light of religion, which they called *cognitio matutina*, we may be able to agree with Ruskin's fine words (engraved on the memorial at Keswick): "The Spirit of God is around you in the air that you breathe, His glory in the light that you see, and in the fruitfulness of the earth and the joy of its creatures He has written for you day by day His revelation, and He has granted you day by day your daily bread."

§ 5. *Scientific Description of Animate Nature not Inconsistent with Religious Interpretation.*

We cannot reach any religious truth or conviction along scientific lines, but we have tried to show that a careful scientific description of Animate Nature is not inconsistent with a spiritual—*i.e.,* religious or philosophical—interpretation.

Although some will not agree, we hold it to be historically true that just as there is a science that knows Nature, so there is a Religion that knows God; and throughout our studies we have not concealed our conviction that it is unprofitable to pit against one another these two distinct ways of working towards truth. For they are not antithetic but complementary.. Perhaps it would be well if the devotees of Science were more aware of its limitations, perhaps it would be well if the religious who have the vision of God knew a little more about His works, but what must be sought after by both is a position from which haply there may be seen the unity of Huxley's science and Wordsworth's vision. The results of Science must, we think, be taken up as "harmonious elements in a system of truth wider than themselves; a system in whose wider light their ultimate significance for life and for the meaning of life would become manifest" (Blewett, 1907, p. 52).

We venture to hope that our study of Animate Nature may have shown it to be less dæmonic and more divine than many, from Aristotle onwards, have supposed; we should regret having spoken at all if our study has led any one to suppose that Animate Nature is not greater than our greatest thought of it. For the facts of the case from first to last are so wonderful that we venture to say that no general impression of Nature reached along scientific or any other lines can be even in the direction of being true that does not sound the note of joyous appreciation and of reverent wonder. As Walt Whitman said, "Prais'd be the fathomless Universe, for life and joy, and for objects and knowledge curious."

Or take part of William Watson's poem:

> "Nay, what is Nature's
> Self, but an endless
> Strife towards music,
> Euphony, rhyme?
>
> Trees in their blooming,
> Tides in their flowing,
> Stars in their circling,
> Tremble with song.
>
> God on His throne is
> Eldest of poets;
> Unto His measures
> Moveth the whole."

But even that is not warm enough. We have missed the substance if the study of Animate Nature leaves us cold. Take rather this from Ralph Hodgson's *Song of Honour:*

> "I heard the universal choir,
> The Sons of Light, exalt their Sire
> With universal song;
> Earth's lowliest and loudest notes,
> Her million times ten million throats,
> Exalt him loud and long,
> And lips and lungs and tongues of grace,
> From every part and every place,
> Within the shining of his face,
> The universal throng."

Let us listen to Goethe, at once scientific investigator and poet:

"Nature! We are surrounded and embraced by her: powerless to separate ourselves from her . . .

We live in her midst and know her not. She is incessantly speaking to us, yet betrays not her secret . . .

She rejoices in illusion. Whoso destroys it in himself and others, him she punishes with the sternest tyranny. Whoso follows her in faith, him she takes as a child to her bosom.

She wraps man in darkness, and makes him for ever long for light. She creates him dependent upon the earth, dull and heavy; and yet is always shaking him until he attempts to soar above it . . .

I praise her and all her works.

She has brought me here and will also lead me away: I trust her. She may scold me, but she will not hate her work.

Every one sees her in his own fashion. She hides under a thousand names and phrases, and is always the same.

I praise her and all her works. She is silent and wise. I trust her."

But we cannot worship Nature. We cannot be grateful to a system. We cannot find abiding human satisfaction in Nature's voices alone. Invigorating, inspiring, and instructive they certainly are, but they are full of perplexities, and it is with a sad wistfulness that we hear their echoes dying away in the quietness of our minds like the calls of curlews on the moor as they pass further into the mist. Happy, then, are those who have what Sir Thomas Browne called "a glimpse of incomprehensibles, and thoughts of things that thoughts but tenderly touch". Shall we not seek to worship Him whom Nature increasingly reveals, from whom all comes and by whom all lives?

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