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The causes of evolution. A Criticism of Casualism

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Filosofia della Scienza. — *The causes of evolution. A Criticism of Casualism.* Nota di GIOVANNI BLANDINO S.J., presentata (*) dal Socio A. STEFANELLI.

RIASSUNTO. — Anche i casualisti ammettono che è estremamente improbabile (e praticamente impossibile) che, durante tutto il periodo di esistenza della Terra, si sia verificata, *anche una sola volta*, la formazione casuale *improvvisa* (o rapida) di una struttura così regolare come quella di un vivente. Però pensano che la formazione *lenta e graduale* di un vivente, influenzata dalla selezione, sia stata probabile, anzi praticamente inevitabile, durante il medesimo periodo d'esistenza della Terra.

Sennonché la supposizione dei casualisti non è esatta. Pensiamo di poter mostrare che, *durante il medesimo periodo complessivo di tempo*, la formazione casuale *graduale* non è stata più probabile della formazione *improvvisa* e che, nella ipotesi casuale, la selezione naturale non ha alcun influsso.

Esaminiamo prima quale sia la probabilità che, nell'ipotesi casuale, una struttura regolare: *a*) si formi improvvisamente, *b*) mantenga il suo grado di regolarità, *c*) « generi » un'altra struttura avente lo stesso grado di regolarità; poi esaminiamo la probabilità che quella struttura si formi gradualmente.

Considerando un ipotetico universo conforme all'ipotesi casuale, cioè un universo in cui le leggi naturali non diano preferenza di realizzazione a nessuna delle strutture possibili (cosicché le strutture di uguale grandezza siano fra loro equiprobabili), si giunge alla seguente conclusione di invarianza delle probabilità: « *Nell'ipotesi di equiprobabilità casuale, la probabilità che una struttura regolare si formi per generazione o per evoluzione graduale non é maggiore della probabilità che quella struttura si formi improvvisamente da materia irregolarmente disposta* ». Cioè: « *Variando le vie di formazione, non varia la probabilità* ».

Nella seconda parte dello scritto viene affermato che: « Nell'ipotesi casuale (cioè nell'ipotesi che nel nostro universo non ci fossero leggi naturali che dessero alle strutture funzionali come i viventi alcuna preferenza) *una struttura funzionale come un vivente* sarebbe *possibile* (anche se *improbabilissima*), invece un *vivente* sarebbe semplicemente *impossibile* ». Il motivo è questo: quella struttura funzionale improbabilissima non sarebbe un vivente, sarebbe una perfetta *statua* anatomica, ma non un vivente, poiché noi per « vivente » intendiamo molto di più: intendiamo una struttura funzionale la quale in base alle leggi naturali (e cioè in base alle forze insite nella materia) ha una relativamente alta probabilità di formazione, un'altissima probabilità di persistenza e un altissima probabilità d'indefinita riproduzione.

Complessivamente, per « vivente » intendiamo un tipo di struttura funzionale che in base alle leggi naturali ha *un'altissima probabilità di esistenza* (includendo nella probabilità di *esistenza*: la probabilità di *formazione*, di *permanenza*, di *riproduzione*). In altri termini, per « vivente » intendiamo una struttura funzionale in favore della quale esistano leggi naturali altamente preferenziali.

(*) Nella seduta del 10 maggio 1986.

Chance Structures

The ideal-chance phenomenon's characteristic feature is the *equiprobability of the single possibilities* [1]. A certain phenomenon may be termed a " chance phenomenon " when it occurs even though there is no natural factor favoring its actualization in a special way; i.e., when that phenomenon occurs although it is equiprobable with the other phenomena of the same level.

Therefore, when in this essay I state that a material structure is a " chance structure ", this means that it has occurred even though there are no laws which favour its actualization in a special way; i.e., it has occurred in spite of the fact that, according to natural laws, it was equiprobable with all other structures of the same size. On the contrary, when I state that a material structure is not a chance structure, it means that *it is not equiprobable* as compared to other possible structures of the same size, but that there are preferential natural laws in its favour, i.e., laws which determine its actualization with a frequency greater than the average frequency of other structures of the same size [2].

The statement, then, that in nature preferential laws exist in favour of a cer tain structure does not at all exclude that, in the realization of that structure, there may be also chance aspects.

Now, a clarification is in order: By saying that a generic structure, having a certain degree of regularity, has *absolute probability* $(1/n)$ I mean that, out of n structures having that size, only *one* has that degree of regularity, whereas the other $(n - 1)$ structures do not have it. Therefore, for every structure having that degree of regularity, there are $(n - 1)$ structures which do not have it.

It is thus possible to form n equinumerous groups of structures [3] in such a way that *only one* of these groups is formed by regular structures, whereas all the other $(n - 1)$ groups are formed by irregular [4] structures.

The Invariance of Probabilities in a " Chance Universe "

Even the supporters of chance theory admit that it is very unlikely (and practically impossible) that, during the whole period of existence of the Earth,

(1) These considerations have already been expounded (much more fully) in my book: *Theories on the Nature of Life*, New York, Philosophical Library, 1969 (unfortunately, this book contains many misprints, because, for illness sake, I could not revise the proofs personally).

(2) It is perhaps advisable to emphasize explicitly that when I state that a certain structure is not a chance structure, it does not mean that it is directly caused by a non-spatial entelechy or by a divine being; it only means that it is directly caused by *natural, but preferential laws*. By the term " natural laws " I imply the intrinsic properties of matter (and, in the last analysis, of intra-atomic particles) which determine the action of matter. More precisely, I imply some peculiar characteristics (in intensity, direction, and sense) of electro-magnetic forces, since these forces are the cause of molecular structures.

(3) The expression " equinumerous groups of structures " means that each of the groups contains the same number of structures.

(4) Irregular or, at least, less regular (that is, not having the required degree of regularity).

the *sudden* (or rapid) chance formation [5] of a structure as regular and functional as that of a human body may have occurred *even if only once*. But they think that the *slow and gradual* chance formation (that is, the formation at the end of a long succession of more and more regular structures) is much more probable than sudden formation.

In my opinion, the supposition of the supporters of chance theory is incorrect. It is possible to demonstrate that, during the same total period of time (for instance, during the five billion years' existence of the Earth), the gradual chance formation of a regular structure has not been more probable than its sudden chance formation.

Now, I will first examine the probability that, by chance, a regular structure may: (*a*) form suddenly; (*b*) maintain its regularity; (*c*) generate another regular structure. I will then examine the probability that, still by chance, the regular structure may form gradually.

Let us consider a hypothetical universe whose laws do not afford preference in existence to any of the possible structures, so that the structures of the same size shall all be equiprobable among themselves. In the following pages I will indicate such a universe by the term " chance universe ". In that hypothetical " chance universe " it happens that:

(*a*) The real probability that a generic regular structure *should form directly from matter irregularly arranged* is, evidently, equal to its absolute probability $(1/n)$.

(*b*) The fact that an anatomically regular structure is formed does not imply that it should maintain itself; the particles forming that structure may not be subject to laws that are necessary for the persistence of that structure. What, then, is the probability that a regular structure should persist, once it is formed ?

If we choose a period of time t as being, on the average, sufficient for a regular structure to be shattered *completely*, then the probability that the degree of regularity obtained shall be maintained during a further period of time t [6] is, once more, $(1/n)$ because after that intervening period of time the preceding regular structure may have been transformed into another structure pertaining to any of the n equinumerous and equiprobable groups (only one of which is composed by structures having the required degree of regularity) [7].

More generally, the probability that the same degree of regularity should persist for k consecutive intervals of time t may be considered as less than $(1/n^k)$.

(5) I.e., the formation directly from irregularly-arranged matter.

(6) I.e., the probability that the regular structure already formed should be followed, after a time t, by another structure having the same degree (or a higher degree) of regularity.

(7) Far smaller is the probability that a structure should persist in the sense that it shall be followed not only by a structure having the same degree of regularity, but precisely by a structure that is morphologically equal or similar (as happens in living bodies).

In order to make this argument clearer, I shall take an example of the kind used to illustrate the principles of statistical mechanics. Let us, then, suppose that we have a container with a flat bottom and that we place in it some differently colored powders so as to produce a pattern.

Should we provide a sufficiently long series of modifying actions (for example, by shaking the container), after a certain time t we will achieve a complete mixing of the powders, resulting in a grey mixture. The same type of grey mixture can be obtained, with great probability, starting from « any » initial pattern.

The probability of producing the initial pattern after the period of time t is, more or less, equal to the probability that, after the same period of time t, we would obtain that same pattern by starting initially from the state of grey mixture (or from any other pattern) [8].

One should bear in mind that, in order that what we have said be true, it is necessary that *the period of time « t » should not be less than the time sufficient for a complete disturbance of the regular structure.* In fact, the probability that, after a period of time shorter than t, a regular structure will be followed by a subsequent regular structure is greater than $(1/n)$; but, in the course of time, that probability rapidly decreases and inevitably reaches $(1/n)$, remaining afterwards practically constant.

Concerning the length of time t, it is important to note that, if the duration of t is more or less the same both for regular and irregular structures, the variation of its duration does not cause a variation of the probability that at a certain moment there should exist a regular structure in the universe.

(*c*) The probability that a regular structure should *produce* (or "*generate*") by chance another structure having the same degree of regularity is $(1/n)$, since the generating structure may produce a structure belonging to any of the n equiprobable groups [9]. There follows that it is far from true that it suffices that one first regular structure form in order to have immediately (by generation) any number of other similar structures.

It is a very strange phenomenon (in such a chance universe) that an organism should have such laws as to be able to produce another similar organism. This is confirmed experimentally by the fact that we have never observed the capacity of generation in any structure which we deem as equiprobable with the structures of its same level.

(*d*) The probability that such a regular structure should form after a gradual evolution, i.e., after a succession of more and more regular structures,

(8) When a structure does not behave as the above pattern of colored powders, it is a sign that there is *something* (i.e., a complex of preferential or orientative laws) that does exist in such a pattern and eliminates the equiprobability of the various arrangements.

(9) Furthermore, the probability that a regular structure should produce another by chance, which not only would have the same degree of regularity, but would be equal or similar, is much lower.

is $(1/n)$, because the preceding structure [10] may be followed by another structure belonging to any of the n equiprobable groups [11].

Now we may formulate the following *Principle of Invariance of Probabilities : In a " chance universe ", the probability that a regular structure should form by generation or by gradual evolution is equal to the probability that the same structure should form immediately from matter irregularly arranged.* In other words: *Varying the modes of formation does not vary probabilities.*

The improbability of the chance formation of a regular structure *in every way* is confirmed by the common experience about those regular structures for which in nature there are certainly no preferential laws; for instance, an industrial plant (which has a regularity no greater than the regularity of a living body) has never been known to form by chance either suddenly or by gradual evolution.

THE IMPOSSIBILITY OF A LIVING STRUCTURE IN A « CHANCE UNIVERSE »

The reader will have noted that in the preceding paragraph I have never spoken of the chance probability of a *living* structure, but only of the chance probability of a *regular and functional* structure, *similar* to a living structure.

The reason for this is that: in a " chance universe " (without preferential laws) a *regular and functional* structure is *possible* (even if *extremely improbable*); on the contrary, a *living* structure is simply *impossible.* In fact, a *living* structure is much more than a *regular and functional* structure. A *living* structure is at least this: " a *regular and functional* structure which has such intrinsic laws as to give to its formation a *relatively high* probability and to its permanency, reproduction, and multiplication [12] a *very high probability* (near to 1) [13].

On the whole, a *living* structure is a functional structure which, on the basis of natural laws, has a *very high probability of existence* (including in the probability of *existence* the probabilities of *formation, permanency,* and *reproduction*). Living structures have a probability of existence *enormously higher* than the average probability of other structures of the same size. Therefore, a *living* structure presupposes the existence of highly preferential laws in its favor.

A few examples may serve to clarify this matter. Let us suppose we have, in a container, a grey powder constituted by a mixture of white and black granules. Let us assume that said granules are in a condition we will call " condi-

(10) More accurately: which precedes by a time t.

(11) The probability of the entire gradual evolution is obviously less than $(1/n)$; $(1/n)$ is the probability of the last transition only. Therefore, in the chance hypothesis, the probability that, during the period of existence of the Earth, a regular structure similar to a living body should form gradually and slowly (for example, through an evolution lasting a billion years) is still much smaller than the probability of its sudden formation (for example, in a few minutes).

(12) Because every living body must generate more than one other living body.

(13) But we can know the existence of such laws only in a probabilistic way by induction.

tion X", characterized by the fact that the various granules do not have any natural law (or active property) of reciprocal attraction or repulsion, so that all possible arrangements (or structures) of the granules are equally probable and no particular structure is favoured with respect to the others. In other words, condition X is characterized by the fact that there are no preferential laws favouring any of the various possible structures.

In condition X it is *possible* that, by repeatedly and gently shaking the container, at a given moment all the white granules will assemble to form a white ball, more or less spherical in shape. This is *possible*, but *extremely improbable*. And, even if said ball has formed, if we go on gently shaking the container, it is very probable that the ball will not continue to exist, but will fall apart, and the white granules will again disperse among the black ones.

Let us examine another condition of the granules, which we will call " condition Y ". Let us assume that we are able to put into each white granule an attractive force for the other white granules and a repulsive one for the black granules. Then, even if the various granules are initially distributed in a more or less homogeneous manner, at each successive shake imparted to the container the white granules will tend to approach one another until they will form a ball formed by white granules and, even if we will continue slightly shaking the container, the ball will tend to stick together. That is, the force of attraction causes the white ball, with high probability, to form and to persist. That law or force is a preferential law in favour of the white ball, i.e., is a law that gives the white ball a probability of existence (i.e., of formation and persistence) much higher than the probability it had in condition X, where all the individual structures were equiprobable.

If we call " living " ball the white ball which, thanks to an intrinsic law is capable, with a high probability, to form and maintain, it is clear that such a " living " ball *cannot form* in condition X, inasmuch as the " living " ball requires a preferential law, whereas in condition X there exists no such preferential law.

Let us go on to another example. Let us consider a crystal of NaCl; in it the atoms get arranged to form a cubic reticle in which an atom of Na and one of Cl regularly alternate.

The formation of this crystal reticle cannot be termed casual. In effect, if, for example, in the crystal reticle we bring about the displacement of an atom of Na, electro-magnetic laws will cause the atom to return to the proper site in the cubic reticle, because only that site is the point of equilibrium of the forces of attraction and repulsion acting on that atom. More generally, all the other possible structures, but different from the cubic reticle, either do not form at all or, if they do form, are unstable and last for a very short time. The cubic reticle structure is formed and subsists because natural laws lead the Na and Cl atoms to those well-defined positions.

In other words, the cubic reticle structure is formed and subsists because in its favour there operate highly preferential laws, i.e., laws which impart to

that structure a frequency of existence (i.e., of formation and permanency) enormously higher than that of each of the other structures possible with those same atoms.

Analogous considerations with those put forth for a crystalline structure obtain also for biological structures. These are likewise structures for which natural laws exist which lend them a frequency of existence (i.e., of formation, permanency, and reproduction) enormously higher than the *average frequency* of the other structures that can be obtained with the same amount of matter.

Each type of living structure requires preferential laws *as much as* each type of crystal requires preferential laws. Therefore, the assumption that a living functional structure may be formed in the absence of preferential laws in its favour is a *contradictory* one, precisely because a living structure requires preferential laws.

SELECTION IN A " CHANCE UNIVERSE "

Perhaps one could think that, if natural selection intervenes, the gradual formation of living structures becomes probable. This is indeed the basis of the conventional theory of evolution by random mutation and selection. But it seems to me that, in a chance universe, selection is meaningless. This criticism can be formulated in two forms:

(1) *Criticism based on the principle of invariance of probabilities.* Selection, i.e., choice of the most fitted structure and elimination of the other less fitted ones, is only efficient if the chosen structure has a greater probability for the transition to a higher degree of regularity than that of the eliminated structures; whereas in the chance hypothesis these probabilities are equal (after a period of time t).

(2) *Criticism based on the principle of impossibility.* Selection caused by the struggle for life has no meaning in a universe where no preferential laws exist and, therefore, no living body can be realized. And if in a universe there are preferential laws for one definite species of living bodies, viable and advantageous mutations are possible only if in that universe there exist preferential laws also in favour of the new living bodies [14].

(14) This type of criticism of Darwinism was initiated by C.E. GUYE (*L'évolution physico-chimique*, Paris, 1922) and by R. Ruyer (*Néo-finalisme*, Paris, 1952).

For further research on the argument developed in this article the reader is referred to my following writings: *Problemas y Teorìas sobre la Naturaleza de la Vida*, Razòn y Fé, Madrid, 1964; *Theories on the Nature of Life*, Philosophical Library, New York, 1969; *Vita, Ordine, Caso*, Morcelliana, Brescia, 1967: *Chance and Design in the Origin and the Evolution of Living Things*, in *Unity through Diversity, A Festschrift for Ludwig von Bertalanffy*, W. Gray and N.D. Rizzo (Ed.), Gordon and Breach, New York, 1973, vol. I, 377-390.

Other my articles on the same subject are: *Osservazioni critiche sul neo-darvinismo*, in « Acc. Naz. Lincei », « Rend. Sc. fis., mat. e nat. » (8) *30*, 960-967 (1961); *Le cause dell'evoluzione*, *Ibidem*, (8) *31*, 490-497 (1961); *Presupposti anticasuali dell'evoluzione della*

The Causes and Modalities of Evolution in Our Universe

The preferential laws inherent in matter are *the basic causes* of living bodies, and therefore of evolution as well. However, these preferential laws may determine evolution following several procedures or modalities.

Among the modalities for the accretion and diffusion of the new mutated genes, it is probable that selection has had a great importance; nevertheless, by no means do I intend to deny that the differential mutability may have been prevalent during some evolutive traits.

As for the amplitude of the phenotypic effect of new genes, it is probable that the traits of slow and gradual evolution may have been caused by micromutations, but in the phases of rapid evolution also macromutations and chains of connected micromutations may have occurred.

Final remarks

Perhaps some Darwinists, faced with my criticism against Darwinism, would reply thus: This criticism is not valid because we do not presuppose a universe with laws that give equiprobability to all the structures of equal size, but on the contrary we admit the laws of physics and chemistry which work in our universe, particularly we admit that natural laws give crystals a high probability of formation and persistence.

My answer is that: Yes, it is true that Darwinists admit the laws of physics and chemistry which give a high preferentiality to regular crystalline structures, but this admission is a *contradiction* of their assertion of casualism. Besides, in order to explain the formation and the evolution of living beings it is also necessary to admit the existence of preferential laws *for every type of living structure.* Living structures require preferential laws as much as crystals do. Without such preferential laws no living being, and therefore no evolution, is possible. *This, it seems to me, is the essential and radical criticism against Darwinian casualistic theory.*

dominanza, Ibidem, (8) *32,* 733-740 (1962); *Sulla probabilità di realizzazione casuale dei corpi viventi, Ibidem,* (8) *32,* 1018-1024 (1962); *Discussione di una frequente argomentazione casualista riguardo ai viventi, Ibidem,* (8) *60,* 709-717 (1976); *Remarks on a calculus by R.A. Fisher about the probability of advantageous casual changes,* in « Monitore Zoologico Italiano », (1963), LXX-LXXI, 275-281.