

EVOLUTIONISM AND HOLISM: TWO DIFFERENT PARADIGMS FOR THE PHENOMENON OF BIOLOGICAL EVOLUTION

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ABSTRACT

The evolutionistic paradigm – the assumption that biological evolution consists in a mere process of ‘descendance with modification from common ancestors’, canonically represented by means of the phylogenetic tree model – can be seen as strictly connected to the classical or deterministic vision of the world, which dominated the 18th and 19th centuries. Research findings in palaeontology, however, have never fully supported the above-mentioned model. Besides, during the 20th century, the conceptual transformations produced by restricted and general relativity, quantum mechanics, cosmology, information theory, research into consciousness, chaos–complexity theory, evolutionary thermodynamics and biosemiotics have radically changed the scientific picture of reality. It is therefore necessary to adopt a more suitable and up-to-date paradigm, according to which nature is not seen anymore as a mere assembly of independent things, subject to the Lamarckian-Darwinian dialectics of ‘chance and necessity’, but as: (1) an extremely complex system with all its parts dynamically coordinated; (2) the evolution of which does not obey the logic of a deterministic linear continuity but that of an indeterministic global discontinuity; and (3) in which the *mind* or psychic dimension, particularly evident in semiotic aspects of the biological world, is an essential and indissoluble part. On the basis of its characteristics, the new paradigm can be generically named holistic, organicistic or systemic.

Keywords: biological evolution, biostratigraphy, evolutionism, holism, palaeontology, *systema naturae*, *taxa*.

1 THE NATURAL PHENOMENON ‘BIOLOGICAL EVOLUTION’ AND ITS INTERPRETATION

Since the foundation of modern palaeontology, nobody can doubt that life on the earth has been characterized by evolution – in the sense that it has not perpetuated itself uniformly but has varied in time, generally becoming more complex. Stated thus, *without further specification*, biological evolution is evidently a great natural phenomenon, i.e. a fundamental and undeniable *fact* that can be verified by anyone directly from the fossil record. *How* this fact occurred – or, exactly, *how* the many different forms of life, including humans, followed each other in time and space – remains nevertheless a great and unanswered question, necessarily linked to the even greater question of the origin of the first cells. The task of scientific research is therefore to clarify this phenomenon by proposing working hypotheses and attempting to verify them. Only verified hypotheses can become valid theories.

Although the causes and modes of evolution are still unclear, most biologists continue to interpret it according to the paradigm (*sensu* Thomas Kuhn) [1] that emerged in France and Great Britain between the end of the 18th century and the first half of the 19th century, but did not dominate naturalistic thought until after Darwin’s *On the Origin of Species* was published in 1859. For historical reasons, this paradigm must be called *evolutionism*. It assumes that biological evolution is a process of ‘descendance with modification from common ancestors’, therefore following ordinary deterministic logic (*post hoc, ergo propter hoc*) and canonically expressed by means of the genealogical or phylogenetic tree model.

The above should be sufficient to indicate the danger of failing to distinguish between *evolution* and *evolutionism*. The former concept, in fact, refers to an objective datum that can be experienced directly like sunlight, whereas the latter is an intellectual construct or a particular way of interpreting

the same datum: specifically, the way adopted by Lamarck, the Darwins (Erasmus and Charles) and many others of their time, whose minds operated on the same wavelength.

This has two major implications. The first is that since any paradigm is a cultural expression and therefore closely linked to a particular historical phase of human thought, and since science must remain open and dynamic if it is not to become mummified in dogmatic constructs, it would be misleading to assume any paradigm as definitive and inviolable. The second implication springs from the observation that any paradigm generally embraces too vast a perspective to be exhausted by a single theory. In relation to the theme in question, it therefore makes little sense to speak of the 'theory of evolution'. Many theories, in fact, have been formulated to explain biological evolution. Besides those proposed by Lamarck and the Darwins, we can remember neo-Lamarckism and neo-Darwinism [2], Berg's nomogenesis [3], Rosa's hologenesis [4], Osborn's aristogenesis [5], the age and area theory of Willis [6], Blanc's cosmolythesis [7], Schindewolf's typostrophism [8], Nilsson's emication [9], modern synthesis theory [10], Eldredge and Gould's punctuated equilibria [11], Kimura's neutralism [12], Barbieri's semantic theory [13] and Lima-de-Faria's theory of auto-evolution [14].

In this article, we propose to briefly re-examine the evolutionistic paradigm in order to verify, more than two centuries after its birth, whether or not it is in line with research findings. In view of the primary importance of palaeontological data, the article will concentrate essentially on that, postponing critical re-examination of neontological data to a later opportunity. In the meantime, the reader can benefit from the good synthetic work by Sarà [15].

2 BEFORE EVOLUTIONISM: THE VIEW OF NATURE AS *SYSTEMA* AND ITS CRYSTALLIZATION

Before the advent of evolutionism, the world was regarded as a coherent whole permeated by a divine presence and intelligence, and therefore as alive, palpitating and creative, and as having outcomes that were often unpredictable and mysterious. It unfolded in an extraordinary hierarchy of complexity, with minerals, plants and animals at the base, humans in the intermediate levels and supernatural entities such as angels in the higher levels. In this order, humans occupied a central position, being considered intermediate between the physical and the metaphysical worlds.

Regarding the present forms of life as being the very ones conceived by the divine mind and fixed on the sixth day of creation, Carl von Linné (1707–1778) proposed classifying them in fundamental categories (taxa) of decreasing breadth and diversification, identified on the basis of appropriately chosen sets of morphological characters. He called the elementary taxa of his classification 'species', assigning to them a Latin binomial nomenclature, while the higher taxa were graded by himself and subsequent naturalists in six levels called 'genera', 'families', 'orders', 'classes', 'types' or 'phyla' and 'kingdoms'.

Although it threw new and bright light on the diversity of forms of life and their relationships, the use of Linnean categories led to a total crystallization of the traditional idea of 'natural order' and to a close relationship between biology and the ecclesiastical dogma of 'special' creation, giving rise to what was later (after the advent of evolutionism) defined as 'fixism'. However, Linné was always aware of the artificial nature of his system and over the years understood that species, and in general taxa below the rank of order, were often difficult to distinguish. In other words, at these levels, the living world was unstable and mutable, lending itself to natural hybridisms and manipulations by cultivators and breeders.

The problem of distinguishing biological taxa is still far from solved, despite the quantity of scientific literature it has generated [16]. In this literature, the species or the fundamental biosystematic unit generally tends to be considered an objective entity with a sure ontological basis, whereas taxa above the rank of species are considered more subjective and conventional. As far as the criteria used to

distinguish species are concerned, the initial approach was strictly morphological and aimed at defining standard typological units, hence attributing secondary importance to variability (or mean divergence from these units), which is however implicit in natural populations. Subsequently an approach based on the physiological criterion of reproductive isolation, considered eminently objective, was adopted. Since the middle of the last century, a 'true' or natural species has generally been considered as any set of mutually fertile organisms reproductively isolated from other similar sets, at least theoretically, irrespective of exterior morphological similarities or otherwise. However, despite the fact that the concept based on reproductive isolation has been called, apparently with a monopolizing claim, 'biological species concept', it has been observed [17, 18] that it does not apply universally to living organisms in general or even to the animal kingdom in particular.

It is significant that at least seven different concepts of species have been proposed [19], suggesting that any attempt to formulate univocal definitions, not only of super-specific taxa, but also of species, is in vain. *The problem of how to distinguish and classify natural biological groups remains therefore unsolved, as it was at the time of Linné.*

Obviously, this conclusion does not imply that living organisms and their evolution should be thought of as disorganized and confused. Nothing obliges us to reject the working hypothesis of a *systema naturae*, though it may not be the rigid and simple structure conceived by Linné. Although distinctions among living organisms differ in sharpness, they are actually extraordinarily numerous and occur at all levels of complexity; but since they regard collective and not individual entities, they should only be considered *distinct in the statistical and not absolute sense*. It follows that biological taxa may be seen as being 'transvariant' among themselves to different degrees in the unitary context of the immense spatiotemporal continuum of which they are a natural and inseparable part.

In this continuum, taxa must be expressed in the three dimensions of space (as statistical units of morphologies linked to geographic distributions and especially to ecosystems) as well as in the fourth dimension (occupying time segments from their appearance to their extinction, in the interval of at least 3–5 billion years from the appearance of the first living cells to today). The palaeontological record indicates, moreover, that taxa may persist stably for millions of years, during which they may take all the mutable morphologies allowed by their intrinsic genetic adaptation potential ('reaction norms' [20]), in response to changing events in their areas of geographical distribution and in their ecosystems. As a result, intra- and inter-group variability of the various taxa, and hence also the respective and mutual differentiation between them, must be subject to continuous fluctuation in the course of time, narrowing and widening in an irregular manner. Since natural species are susceptible to variations and differentiations that may be quite radical (e.g. insular and subterranean adaptations), they may be much broader and more versatile than conventional species.

It is worth noting that this interpretative approach echoes the position of the German zoologist Otto Kleinschmidt [21], who at the beginning of last century proposed replacing the classical concept of species with that of *Formenkreis* or 'circle of forms'. Kleinschmidt did not mean 'circle' in the sense of the geometric figure, but in that of *coherent qualitative spatiotemporal unit* (like the *Wienerkreis* or the Circle of Vienna: a club or congregation of persons sharing a 'basic idea'), generally including more conventional species.

3 THE ADVENT OF EVOLUTIONISM AND REPUDIATION OF THE *SYSTEMA NATURAE*

After Linné, scholars of life generally followed in his footsteps; however an underlying current of doubt about the fixed nature of species existed and progressively increased. This doubt manifested more openly in a badly governed country that was entering the stormy years of its revolution. In the French intellectual world, there was increasing interest in human beings, human destiny, the

origins of society and the struggle of the poor and oppressed. The human population was studied in relation to food supply and similarities were drawn with primitive life. Resentment of ecclesiastical authoritarianism, immobility and dogmatism helped the spread of restrictive philosophical determinism and elevated nature and the 'second book of revelation' above the written book. It was in this intellectual climate, which had repercussions in nearby England and was reinforced by growing faith in the industrial revolution, scientific-technological progress and the superiority of western man, that a long list of personalities put pen to paper: Benoît de Maillet (1656–1738), Bernard Le Bouvier de Fontenelle (1657–1757), Pierre-Louis Moreau de Maupertuis (1698–1759), Jean-Louis Leclerc de Buffon (1707–1788), Julien Offroy Delamétherie (1709–1751), Denis Diderot (1713–1784), Erasmus Darwin (1731–1802), Jean-Baptiste Monet de Lamarck (1744–1829), William Wells (1757–1817), William Lawrence (1783–1867), James Prichard (1786–1848), Patrick Matthew (1790–1874), Robert Grant (1793–1874), Charles Lyell (1797–1875), Robert Chambers (1802–1871), Edward Blyth (1810–1873), Charles Naudin (1815–1899), Charles Darwin (1809–1882) and Alfred Russel Wallace (1823–1913). Thus, an evolutionistic paradigm took form and consolidated. According to this paradigm, all forms of life were the result of a long, slow natural process of 'descendance with modification from common ancestors', and therefore implied a direct hereditary link and the explanation by means of the predecessors. If until then the main task of naturalists had been to look for models or 'structural plans' (*Baupläne*), i.e. the *archetypes*, on the basis of which biological products of nature were moulded, all this ceased to have any sense for evolutionists, as those archetypes simply did not exist. There were no barriers or qualitative discontinuities between groups of living beings, only voids or gaps caused in time by loss of many links of the chain of evolutionary transformation. Since these groups had a common origin and were therefore all related, the job of the naturalists became essentially that of reconstructing those genealogies as faithfully as possible.

What were the mechanisms of the process of transformation? Only speculative answers to this question were offered. For example, in its final formulation, the thesis of Lamarck, the father of evolutionism, was that simple organisms were generated spontaneously as a special effect of the combined actions of the environmental 'fluids'. Once these organisms had been formed, a special physical property (that he called 'orgasm') caused 'organic movement' in their internal fluids, resulting in organization into organs and functions. In other words, just as environmental fluids moulded the earth's surface, internal fluids of living organisms moulded these beings; hence biological organization was simply the result of repeated movements of organic fluids and continuous changes that the fluids underwent by combination of different substances and break-up of compounds obtained from those combinations. Each living form then perpetuated itself in its descendants until new circumstances generated new types of movements leading to new organic conformations. 'With the concurrence of all these causes, the laws of nature, much time and an inexhaustible diversity of circumstances, the living bodies of all the orders were formed', wrote Lamarck in his *Recherches sur l'organisation des corps vivants* (1802). Moreover, in his subsequent work, *Histoire naturelle des animaux sans vertèbres* (1815), vol. I, he took pains to specify that no purpose was implied in the process of transformation of living forms, but that everything could be ascribed to physical factors of an essentially mechanical or deterministic nature: 'Above all in living beings, especially animals, it seemed possible to discern a purpose in the operations of nature. Again, any purpose is mere appearance and not real. Indeed, an order of things subsists in all types of animal organisms. By progressive development of the various parts driven by environmental conditions, this order merely leads to what seems to us to be a purpose, but is substantially a necessity.' ([22], pp. 52, 73).

Unlike Lamarck, for Prichard, Lawrence, Wells, Naudin and Wallace, competition and natural selection were essentially what caused changes in the organization of living beings. However they agreed with the father of evolutionism that these changes occurred without any pre-established

aim [23]. As far as Erasmus and Charles Darwin were concerned, environmental pressure, use/non-use of body organs and competition could all give rise to modifications that were transmitted to the progeny and preserved by natural selection [24]. Charles Darwin, however, remained open to changes of mind, corrections and specifications, to the extent that he actually reconsidered and reduced the importance of natural selection. 'I now admit (...) that in the earlier editions of my *Origin of Species* I perhaps attributed too much to the action of natural selection or the survival of the fittest. (...) I did not formerly consider sufficiently the existence of structures, which, as far as we can at present judge, are neither beneficial nor injurious, and this I believe to be one of the greatest oversights as yet detected in my work' [25].

4 THE BIRTH OF PALAEONTOLOGY AND BIOSTRATIGRAPHY

Besides being one of the greatest zoologists of all times and earning the title of father of comparative anatomy, Georges Dagobert de Cuvier (1769–1832), the founder of palaeontology, was the first to study the phenomenon of biological evolution by a scientific method. Colleague in the same institute as Lamarck, he attributed the evolutionistic paradigm to 'creators of systems', too preoccupied with speculation to undertake patient, constant and accurate fieldwork. With Alexandre Brongniart (1770–1847), Cuvier had gone on field trips in the Seine basin nearly every week for four years to determine the exact vertical succession of sedimentary strata and their fossils and to decipher their geological history. With their work *Essai sur la géographie des environs de Paris* (1811), the two French scholars laid the foundations of modern biostratigraphy.

Fourteen years later, Cuvier summed up the results of his research in *Discours sur les révolutions de la surface du globe*: (1) in the past, the earth's surface had been populated by forms of animals different from those found at present and bore the signs of sudden catastrophic events; (2) the time succession of animal forms showed an increase in complexity: first 'oviparous quadrupeds' (reptiles), then 'viviparous quadrupeds' (mammals); (3) it was nevertheless impossible to interpret the different animal groups as regular steps that merged perfectly with each other, in a scale of increasing complexity; (4) this situation was the same as the present day one, in which examination and comparison of animal forms always led to a well-defined number of structural patterns clearly separated from each other (the types or phyla); (5) as far as one could see from the representations and mummifications of many species of animals by the ancient Egyptians, these species had not changed at all over thousands of years.

Since Cuvier has been made out, every now and then, as a retrograde and reactionary 'creationist', it is important to remember what he wrote about changes in the configurations of living groups in the course of time: 'When I sustain that rock layers contain the bones of various genera and overlying sedimentary layers those of various species that no longer exist, I am not saying that there was a new creation to produce the species existing today; I merely say that they did not exist in places where they are observed today, and that they must therefore have come from elsewhere. Let us suppose, for example, that a great sea transgression covers the continent of New Holland (Australia) with sand and other detritus. The material buries the bodies of kangaroos, koalas, dasyures, bandicoots, cuscuses, echidnas and platypuses and completely destroys species of all these genera, since none of them now exist in other countries. If this revolution makes many small areas emerge between New Holland and the continent of Asia, a bridge is created for elephants, rhinoceroses, buffaloes, horses, camels, tigers and all the other Asian quadrupeds to populate a land where they were previously unknown. Suppose a naturalist studies all these living animals and then digs in the soil, finding the remains of completely different animals. What New Holland would be in this case is what Europe, Siberia and much of the Americas are; perhaps one day, when all the other countries and New Holland itself are explored, we will find that they have all been through revolutions of this kind, that is, mutual

exchange of productions. To take our supposition further, if after this transport of Asian animals into New Holland, another revolution destroys Asia, their original home, people who observed them in New Holland, their second home, would wonder where they came from, just as we wonder where our animals came from.' (Cuvier 1825, chapter 'Les espèces perdue ne sont pas des variétés des espèces vivants') [26].

According to Cuvier, science could not claim more than this. All the talk of a primeval earth ruled by water and fire, by forms of life generated in the water and later adapting to the various changes of the globe surface, were only fantasies or 'philosophical novels', like those written to entertain the cultured public in the late 18th century.

Since then, palaeontology has given enormous contributions to natural science. Building patiently on the foundations of the actualist methodological criterion and of the stratigraphical postulates, it has made it possible to draw up a reliable and increasingly detailed picture of life on our planet. And this picture substantially confirms Cuvier's statements.

For example, let us consider the thesis of catastrophic events that occurred during the history of the earth. Until the 1980s, any argument based on catastrophes was greeted with suspicion and contempt within the academic world, since on the basis of Lyell's uniformitarianism, it was considered axiomatic that geo-palaeontological phenomena should be hypothesized and explained in terms of slow and gradual changes. Thirty years after the discovery of the anomalous abundance of iridium in the final Mesozoic stratigraphic levels outcropping near Gubbio (Central Italy), the intellectual climate has considerably changed [27]. Today, it is serenely accepted that although catastrophes of planetary importance, such as would be produced by the impact of a comet or a large asteroid, have a negligible probability of occurring in the limited span of a human life, their probability over the hundreds of thousands or millions of years of geological history is not small. Besides, celestial bodies are known to have fallen and caused catastrophes on our planet not only in the past eras but also in human memory, as shown by the one that exploded violently in the eastern Siberian taiga on 30 June 1908.

As we shall underline, Cuvier's hypotheses of the discontinuous course of biological evolution and of the stability of life forms have also proven to be correct. The only hypothesis proven to be wrong (but it would be absurd to blame it upon Cuvier, since the study of sedimentary successions had only just begun and thanks to him) was that of the substitution of extinct faunas by other faunas from elsewhere. Actually, every new fauna did not come from elsewhere (i.e. it was not coeval with the extinct fauna and distributed in a different geographic area), but always appeared *ex novo*, in a manner that has never been clarified.

On the basis of absolute dating of meteorites, it is generally accepted that the earth formed about 4.7 billion years ago by condensation and accretion of the nebula from which the sun, planets, satellites, asteroids and comets are thought to have originated. Since that event, the picture of the earth's history provided by geology is that of an immense pile of units of rock strata of different ranks or entities, established on the objective basis of their fossil content in all parts of the world; these are 'read' in sequence from bottom to top. The main rock strata units are known as eonothems, subdivided into erathems, systems, series and stages, while the time intervals of deposition of these units are known as eons, eras, periods, epochs and ages respectively.

The Hadean eon (from the Greek *Hades* or underworld) extended from the birth of the earth to the consolidation of its crust. This seemed to have occurred 4.4–4.0 billion years ago, as the surface was cooled by torrential rains involved in the generation of the atmosphere.

The Archaean (archaic) eon was made up of four eras and extended from the consolidation of the crust to about 2.5 billion years ago. In the corresponding eonothem, traces of life in the form of fossils of bacteria-type cells could be found.

The Proterozoic ('with primitive animal life') eon consisted of three eras and extended from 2.5 billion to about half a billion years ago. The upper half of the corresponding eonothem contained fossils of

nucleate monocellular planktonic organisms. In the seas of the Late Proterozoic, the first multicellular organisms also appeared, namely algae, plants and a few true animals, associated with an abundance of strange, soft-bodied organisms that are not unanimously assigned to known biological phyla.

The Phanerozoic ('with evident animal life') eon was the last half billion years and its eonothem included abundant plant and animal fossils, clearly visible to the naked eye. Although they only embrace the last eighth of the earth's history, the events of Phanerozoic life can be reconstructed with considerable accuracy by virtue of their rich fossil record of marine plankton and invertebrates. This eon was thus divided into three erathems/eras, known as the Palaeozoic era (consisting of Cambrian, Ordovician, Silurian, Devonian, Carboniferous and Permian systems/periods), the Mesozoic era (consisting of Triassic, Jurassic and Cretaceous systems/periods) and the Cenozoic era (consisting of Palaeogene and Neogene systems/periods, followed by the Quaternary period). Ignoring invertebrates, the first fishes, amphibians and reptiles appeared in the Palaeozoic era; the latter reigned in the Mesozoic era when mammals and birds also appeared, the latter not becoming dominant until the Cenozoic era. The remains that can be assigned for certain to humans only appear in the Quaternary period. As far as we know, our species does not go back more than 160,000 years (findings from Herto, Ethiopia).

5 THE ENIGMA OF THE ORIGIN OF THE FIRST CELLS

Until 4.4 billion years ago in the Hadean eon, the surface of our planet was an ocean of hot magma under constant bombardment by asteroids and meteorites. Then surface temperatures fell and a solid crust formed with oceanic basins of hot water and continents subject to erosion. This marked the beginning of the Archaean eon and set the scene for the appearance of life: an event that seems to have occurred over a relatively short interval of time. It is considered highly probable that the microstructures present in cherts at Apex in northwest Australia, dated almost 3.5 billion years, are fossilised bacterial cells. It also seems probable that carbon present in cherts at Isua in Western Greenland, dated 3.8 billion years, is of biological origin. If the palaeontological material from Apex and Isua is confirmed to be authentic, we will have to conclude that life is almost as old as the oldest known rocks, since it appeared more or less when surface conditions of the earth were such as to permit its existence. In any case, even if the above 'biotraces' are not confirmed, how did this extraordinary and unpredictable event occur?

Any attempt to answer this question begets another, namely, how does a living cell differ from all other physical systems?

Many answers have been given, but the most appropriate seems to be that living cells differ from all other physical systems by virtue of the increase in complexity inherent in their epigenetic development: i.e. due to a series of subsequent geneses, each leading to the appearance of new structures and new functions. No machine or non-living physical system can increase its complexity as can the simplest living cell.

One of the milestones of 20th century science was the discovery that the information contained in the genes of DNA is determined by the *linear* order of its nucleotides, in the same way as the information contained in a word is determined by the linear order of its letters: each nucleotide triplet 'calls' a specific amino acid to build a protein molecule. However, the functions of proteins depend solely on the *three-dimensional* dispositions of their amino acids, and since genes clearly cannot transport the information necessary for protein assembly into that space (it would be like writing 'apricot' on a strip of paper and expecting the paper ... to roll up and become a real apricot!), the enormous quantity of information necessary for this assemblage can only come from the increase in complexity inherent in an epigenetic-type process.

As shown by Marcello Barbieri [28], a physical system can increase in complexity only if it has a memory and a translation code. *Memories and translation codes* (such as the linguistic codes exclusive

to our species, the genetic code present practically in all organisms and many other still undeciphered biological codes) *must therefore be considered fundamental components of all organisms*.

This conclusion radically transforms our view of the living world, excluding its interpretation as a mere assembly of objects dominated by the rigidly deterministic dialectic of 'chance and necessity', and bestowing features hitherto regarded as exclusive to the human *mind*. This means that the origin of living systems cannot be explained without at the same time explaining the origin of the memories and translation codes they contain.

6 THE DISCONTINUOUS NATURE OF BIOLOGICAL EVOLUTION

As we have seen, there were only bacterial or prokaryotic cells in the Archaean era. Eukaryotic organisms abruptly appeared in the Proterozoic eon, almost 2 billion years after the first prokaryotes, in the form of marine protists with a planktonic lifestyle, mostly assigned to the extinct and *incertae sedis* group of the Acritarchs. As is known, eukaryotic cells are not only about 10 times larger than bacterial cells, but their genetic material is also protected in a nucleus and their cytoplasm contains highly complex organelles.

After this grand event of biological discontinuity, there seem to have been no widespread 'attempts' by protists to unite in colonies or multicellular structures. To the contrary, it seems that the establishment of multicellular eukaryotic life began 680–620 million years ago with a series of 'explosions of differentiation', often in close succession, marking the end of the Proterozoic eon and the start of the Phanerozoic eon. The steps of the phenomenon were: (1) marine floras of the type found in southern China; (2) enigmatic soft-bodied marine organisms of the type found at Ediacara in Australia; (3) abundant fossil traces (tracks, burrows, and trails in surface sedimentary levels of the sea floor) in the lowest stage/age of the Cambrian; (4) forms with hard parts in subsequent stages/ages of Lower Cambrian. The last step corresponds to a succession of extraordinary 'explosions', each of which occurred in not more than 2–5 million years: true 'flashes of lightning' in geological time.

Like other events, the appearance of these forms in the Lower Cambrian occurred relatively simultaneously in all parts of the world and marked the dawn of all known zoological phyla, as well as many unknown or *incertae sedis* taxa that subsequently became extinct.

It is disconcerting that no other basic evolutionary novelty has occurred since the great discontinuities of Lower Cambrian. Although phanerozoic floras and faunas have changed from one period to another and especially from one era to another, these changes merely consist in *variations on basic themes that have remained unchanged for more than half a billion years*. In other words, the fauna of the Palaeozoic era were neither less complex nor less diversified, but simply different from that of the Mesozoic and Cenozoic eras, never deviating from the anatomical patterns of the phyla established at the beginning of Cambrian period.

The discontinuity of biological evolution is not only a characteristic of the higher systematic categories such as kingdoms, phyla, classes, orders and families, but also of the lower ones such as genera and species, although in this case it may be less clear due to their more unstable and indefinite consistency. Indeed, the fossil record is rich in so-called 'microevolutionary' series, what is more generally used in biostratigraphy, in which gradual and continuous changes can be observed in certain directions, even over millions of years. In most cases, the series in question can be interpreted as intraspecific adaptations to environmental changes that continued for long periods of time; however, as we said, this interpretation appears plausible only if natural species are regarded as having broader adaptive potential than conventional species.

It is significant that discontinuity in the fossil record forced palaeontologists to use very different evolutionary models from those postulated by Lamarck and Darwin, at least until the first decade

of the last century, from the typostrophic processes of Karl Beurlen [29] and Otto Schindewolf [8] to the more recent punctuated equilibria of Niles Eldredge and Stephen Jay Gould [11]. For every biological taxon, these models predict a very fast brief initial phase of constitution followed by a much longer phase of stability that ends with extinction.

However, if the phase of evolutionary change or constitution of new groups was really so rapid and brief (of the order of thousands, not millions, of years: i.e. true blinks in geological time), the probability of finding fossils that could record it would be very small, if not zero. The clamorous implications of this are that *palaeontology cannot provide any unequivocal proof of the existence of those transitions from one group to another that are the essence of the evolutionistic paradigm*, raising the legitimate suspicion that the postulation of phases of rapid change at the appearance of evolutionary 'novelties' is nothing more than an *ad hoc* solution to something that completely eludes our understanding.

After about two centuries of untiring work on fossils from all over the world and from all levels of the stratigraphic sequence, it is truly difficult to reject the conclusion that it is a vain hope to link past living forms with each other and with present ones by means of common linear relations of cause and effect developing in a continuous manner in time. In other words, trying to represent the history of life as a genealogical tree, as required by evolutionism, seems to be a hopeless enterprise. Indeed, for a tree to exist, there must be a trunk with roots and as many bifurcations as there are branches; roots and bifurcations are systematically *absent or nebulous* in the fossil record.

A great many examples could be cited in support of this assertion. One regarding the evolution of man was published by us some years ago [30] and subsequent palaeoanthropological contributions have not even scratched the surface of the underlying thesis.

7 MYRIADS OF 'SEGMENTS OF EXISTENCE' COORDINATED IN 'EVOLUTIONARY ECOLOGICAL UNITS'

After what we have seen, it should now be evident that the picture of biological evolution provided by the fossil record does not coincide with that postulated by evolutionism. Whether we like it or not, palaeontology does not provide the image of an immense and intricate genealogical tree. What we see is a myriad of 'segments of existence' of different lengths, lying parallel in the vertical direction of time, paradoxically and mockingly ... suspended in mid air! However, the 'segments' are not actually separate or suspended in mid air because, as we saw when we discussed the problem of distinguishing natural biological groups, they are not at all 'segments', but rather *statistical congregations in mutual and dynamic interaction* within the chronotope (or spatiotemporal continuum) of the *systema naturae*.

That is not all, because the model of punctuated equilibria is increasingly turning out to be a special case of a broader model that Carlton Brett and Gordon Baird called 'coordinated stasis' 10 years ago [31], but had in any case already emerged from the results of research begun at least 20 years earlier by Arthur Boucot [32, 33].

Studying the fossil record in detail, Boucot realised that events of stability and change were not distributed randomly in the stratigraphic sequence but were organized in communities of organisms constituting 'evolutionary ecologic units' (EEUs). And these EEUs also regularly turned out to appear suddenly, to remain substantially unchanged for different tracts of geological time, and finally to become extinct just as suddenly as they appeared. Since the start of the Phanerozoic eon, at least nine such EEUs can be recognized, having durations of 10–100 million years [34].

Boucot's concept of EEUs is now widely known. However, though clearly pointed out by the author, it is less known that EEUs with wide geographical–temporal distribution consist in turn of subunits made up of large groups of taxa in regular evolutionary stasis. It can be deduced that *stability was the norm and evolutionary change was rare and always discontinuous throughout*

the history of life. 'The pattern indicates that stability is the norm throughout life's history and that evolutionary change is rare and discontinuous. Moreover, (...) the pattern indicates that both significant morphological change within organisms and major ecological restructuring occur in a very small proportion of Earth's history, perhaps less than one percent of geologic time' ([35], p. 12). What is more, every major ecological restructuring – corresponding to a transition from one EEU to the next – does not appear to be correlated with the degree of environmental stability or with the competition between communities, since it often occurs in a biosphere, imbalanced and devastated by catastrophic events of mass extinction, rather than crowded with competing species as in ordinary times.

The fundamental question cannot be avoided. The vertical distribution of myriads of 'segments of existence' that describe biological evolution is not random. Is it therefore anti-scientific mysticism to consider the prospect that this distribution represents the implementation of a 'project' intrinsic to nature?

First, prokaryotes and then eukaryotes appeared on the earth; the latter first included protists and subsequently multicellular plants and animals. In the plant kingdom, algae came first, followed by pteridophytes, then gymnosperms and finally angiosperms. In the animal kingdom, phylum chordates, first came agnatha, followed by fishes, amphibians, reptiles, mammals and birds and finally *Homo neanderthalensis* and *Homo sapiens*. Can this extraordinary sequence really be fortuitous and 'contingent' rather than reflecting a plan of nature?

Even without considering the patterns of anatomical organization of living groups, but only their external morphologies, how can one fail to be struck by the fact that the latter, far from varying infinitely, tend to regularly recur in space and time, like a finite spectrum of structural models and schemes: simple models such as spheres, spirals, cones and fractals and complex models such as those occurring in cases of so-called 'convergence' and 'parallelism'? This so struck Lima-de-Faria [14] as to induce him to reject any interpretation of a selectionist character.

Moreover, how is it possible to ignore the complex and articulated system of 'natural cycles' (of oxygen, carbon, nitrogen, phosphorus, etc.) of which organisms are a coherent, active and determinant part, in the absence of which life would be impossible? Darwin did not consider this at all. Is it really possible to regard all this as a web of 'coincidences'? Could not the idea of a grand structural plan of nature be a legitimate working hypothesis?

The author of this paper is convinced that interpreting the natural phenomenon of biological evolution by means of a *holistic* (or *organicistic* or *systemic*) paradigm does not violate scientific canons. From the point of view of this paradigm, just as the parts of a work of art have meaning by virtue of their coherent relations with the other parts, in the framework of an underlying idea, biological groups are neither isolated nor independent from other present, past and future biological groups. Unlike the static system of Linné, the *systema naturae* is dynamic and evolving according to intrinsic laws, producing appearances and extinctions, long periods of relative stability and periods of sudden and radical changes. Its underlying logic is not rigidly deterministic, linear or local, but rather creatively indeterministic, non-linear and global. According to this paradigm, it no longer makes sense to construct genealogical trees by searching for common progenitors and missing links between groups. In the words of Pirandello, these progenitors and links turn out to be 'one, none and a hundred thousand'.

8 NON-DETERMINISM RULES THE PHYSICAL WORLD

During the 20th century, the conceptual transformations produced by restricted and general relativity, quantum mechanics, cosmology, information theory, research into consciousness, chaos–complexity theory, evolutionary thermodynamics and semiotic biology have changed radically the scientific

picture of reality. Although this fact has happened very slowly and often in a confused way (chaos–complexity theory and biosemiotics, for example, notwithstanding were inaugurated respectively at the end of the 19th century by Henri Poincaré [36] and at the beginning of the 20th century by Jakob von Uexküll [37–39], remained neglected fields for many decades, until taken up by mathematicians such as René Thom [40] and David Ruelle [41] and by biologists such as Marcello Barbieri [13, 28] and Jesper Hoffmeyer [42]), its consequence has been the collapse of classical or deterministic view of the world.

In its restrictive philosophical sense, according to which the future depends solely on the past, classical determinism constitutes practically the basic framework of the evolutionistic paradigm. Although this determinism does not eliminate but somehow confirm the possibility of a design *a priori* underlying the development of the physical world, it confines this design to a limited category: that of a nature dominated by *necessity* and completely devoid of *freedom*. Once certain initial conditions or ‘causes’ have been established, certain effects *necessarily* follow; so, if the initial ‘causes’ are known, the effects are completely predictable. When the initial conditions cannot be known (as when the dice are shaken and cast), the result of the process is said to be the product of ‘chance’. Here, however, we have not escaped from determinism, as the process is still considered to be governed by laws of necessity.

Despite all the illusions of the mechanism of the 18th century, today we nevertheless know that determinism only seems to subsist because there are phenomena such as astronomical ones in which it can almost be verified, and deviations from predicted would only manifest on an enormously dilated time scale. The rule governing the normal physical world is non-determinism, since in complex systems the ‘initial causes’ can give rise to a spectrum of different results, implying that the evolution of this world cannot be predicted exactly. Hence, if what we call ‘chance’ today is still disputable (and the casting of dice is only *one* type of chance), ‘necessity’ can no longer be considered a dominant condition of the physical world. *The universe described by post-19th century science is increasingly emerging as a highly complex system, profoundly connected in all its parts and evolving under non-linear, non-local and non-predictable laws.*

So, in proposing the idea of a *systema naturae* which evolves ‘as a whole’ and within which discrete spatiotemporal entities (the various taxa and biosystematic groups) continually take form, persist and disappear in an interacting way, we glimpse a situation of crisis in contemporary biology very similar to that afflicting physics in the first decades of the last century. At that time, it was realized that the foundations of the material world did not obey the laws of classical mechanics, but could only be explained in logical mathematical terms by means of ‘wave functions’ expressing probabilities of interaction. Similarly, today we realize that the search for phylogenetic connections between taxa in a linear deterministic sense is in vain, since nothing authorizes us to consider that such connections ever existed. The only thing left to do is to tackle the study of biological groups by a non-deterministic statistical approach, quantitatively surveying their characters (morphological, physiological, biochemical, ethological etc.) and establishing their mutual distance *in the framework of the system to which they belong*, on the basis of the overall ‘degree of transvariation’ existing among them. Any relation between living groups must from now on be viewed in the perspective of the spatiotemporal system of which they are an integral part, and no longer as if they were separate and independent ‘objects’.

9 CONCLUSIONS

To summarize our point of view:

- the evolutionistic paradigm is not confirmed by the fossil record;
- it is therefore necessary to find a more suitable paradigm.

Instead of seeing nature as a mere assembly of independent things, subject to the Lamarckian–Darwinian dialectics of ‘chance and necessity’, we can see nature as:

- an extremely complex system with all its parts dynamically coordinated,
- the evolution of which does not obey the logic of the deterministic linear continuity of classical physics but that of the indeterministic global discontinuity of quantum physics,
- and in which the *mind* or psychic dimension, which can be glimpsed particularly in the semiotics of the biological world, is an essential and indissoluble part [43–48].

This different paradigm can be generically named holistic, organicistic or systemic.

Although it is superfluous for us [49], for some it may be useful to point out that the new paradigm, unlike any confused and unverifiable form of ‘creationism’, remains completely open to research and scientific judgement.

REFERENCES

- [1] Kuhn, T.S., *The Structure of Scientific Revolutions*, University of Chicago Press: Chicago, 1962.
- [2] Reid, R.G.B., *Evolutionary Theory, the Unfinished Synthesis*, Croom Helm: London and Sydney, 1985.
- [3] Berg, L.S., *Nomogenesis, or Evolution Determined by Law*, Constable: London, 1926.
- [4] Rosa, D., *L'Ologénèse. Nouvelle théorie de l'évolution et de la distribution géographique des êtres vivants*, Librairie Félix Alcan: Paris, 1931.
- [5] Osborn, H.F., Aristogenesis, the observed order of biomechanical evolution. *Proceedings of National Academy of Science, USA*, **19**(7), pp. 699–703, 1933.
- [6] Willis, J.C., *The Course of Evolution by Differentiation or Divergent Mutation Rather than by Selection*, Cambridge University Press: Cambridge, 1940.
- [7] Blanc, A.C., Cosmolisi. Interpretazione genetico-storica della entità degli aggruppamenti biologici ed etnologici. *Rivista di Antropologia*, **34**, 1943.
- [8] Schindewolf, O.H., *Grundfragen der Paläontologie*, Schweizerbart: Stuttgart, 1950.
- [9] Nilsson, H., *Synthetische Artbildung (I-II)*, Gleerups: Lund, 1953.
- [10] Huxley, J., *Evolution, the Modern Synthesis*, Allen & Unwin: London, 1963.
- [11] Eldredge, N. & Gould, S.J., Punctuated equilibria: an alternative to phyletic gradualism. *Models in Paleobiology*, ed. T.J.M. Schopf, Freeman, Cooper & Co.: San Francisco, pp. 82–115, 1972.
- [12] Kimura, M., *The Neutral Theory of Molecular Evolution*, Cambridge University Press: Cambridge, 1983.
- [13] Barbieri, M., *The Semantic Theory of Evolution*, Harwood Academic Publishers: London, 1985.
- [14] Lima-de-Faria, A., *Evolution Without Selection: Form and Function by Autoevolution*. Elsevier: Amsterdam, New York and London, 1988.
- [15] Sarà, M., *L'evoluzione costruttiva. I fattori d'interazione, cooperazione e organizzazione*. UTET Libreria: Torino, 2005.
- [16] Berlocher, S.H., Origins: a brief history of research on speciation. *Endless forms: species and speciation*, eds. D.J. Howard & S.H. Berlocher, Oxford University Press: Oxford, pp. 3–15, 1998.
- [17] Simonetta, A.M., Una critica del pensiero dicotomico in sistematica. *Systema Naturae*, **2**, pp. 55–64, 1999.
- [18] Schilthuizen, M., *Frogs, Flies and Dandelions*, Oxford University Press: Oxford, 2001.
- [19] Harrison, R.G., Linking evolutionary pattern and process: the relevance of species concepts for the study of speciation. *Endless forms: species and speciation*, eds. D.J. Howard & S.H. Berlocher, Oxford University Press: Oxford, pp. 19–31, 1998.

- [20] Schlichting, C.D. & Pigliucci, M., *Phenotypic Evolution: A Reaction Norm Perspective*, Sinauer: Sunderland, 1998.
- [21] Kleinschmidt, O., *The Formenkreis Theory and the Progress of the Organic World*, Witherby: London, 1930.
- [22] Corsi, P., *Lamarck: Il mondo naturale si affaccia all'evoluzione*, I grandi della scienza, no. 18, Le Scienze, Milan, 2000.
- [23] Darlington, C.D., *Darwin's Place in History*, Blackwell: Oxford, 1959.
- [24] Eiseley, L., *Darwin's Century. Evolution and the Men who Discovered It*, Doubleday: London, 1958.
- [25] Darwin, C., *The Descent of Man, and Selection in Relation to Sex*, (Chapter II), part I, Murray: London, 1871. Consulted edition: The Thinker's Library, no. 12, p. 64., Watts & Co.: London, 1930.
- [26] Cuvier, G., *Discours sur les révolutions de la surface du globe, et sur les changemens qu'elles ont produit dans le règne animal*, 1825 www.victorianweb.org/science/science_texts/cuvier/cuvier-F15.htm.
- [27] Alvarez, W., *T. rex and the Crater of the Doom*, Princeton University Press: Princeton, NJ, 1997.
- [28] Barbieri, M., *The Organic Codes*, Cambridge University Press: Cambridge, UK, 2003.
- [29] Beurlen, K., *Vergleichende Stammesgeschichte*, Borntraeger: Berlin, 1930.
- [30] Fondi, R., Fratello Neandertal. Tre diverse interpretazioni dell'evoluzione del genere umano. *Systema Naturae*, **2**, pp. 7–54, 1999.
- [31] Brett, C.E. & Baird, G.C., Coordinated stasis and evolutionary ecology of Silurian-Devonian faunas in the Appalachian basin. *New Approaches to Speciation in the Fossil Record*, eds. d.H. Erwin & R.L. Anstey, Columbia University Press: New York, pp. 285–315, 1995.
- [32] Boucot, A.J., Does evolution take place in an ecological vacuum? II. *Journal of Paleontology*, **57**, pp. 1–30, 1983.
- [33] Boucot, A.J., Evolution of communities. *Palaeobiology: A Synthesis*, eds. D. Briggs & P. Crowther, Blackwell: Oxford, 1990.
- [34] Sheehan, P.M., A new look at ecologic evolutionary units (EEUs). *Palaeogeography, Palaeoclimatology, Palaeoecology* (Special issue on New perspectives on faunal stability in the fossil record), **127(1–4)**, pp. 21–32, 1996.
- [35] Brett, C.E., Ivany, L.C. & Schopf, K.M., Coordinated stasis: an overview. *Palaeogeography, Palaeoclimatology, Palaeoecology* (Special issue on New perspectives on faunal stability in the fossil record), **127(1–4)**, pp. 1–20, 1996.
- [36] Briggs, J. & Peat, F.D., *Turbulent Mirror*, Harper & Row: New York, 1989.
- [37] von Uexküll, J., *Theoretische Biologie*, Springer: Berlin, 1928.
- [38] von Uexküll J., *Bedeutungslehre*, Bios (Abh. Theor. Biol. Gesch. Philos. organ. Naturw.). Bd. 10, Barth: Leipzig, 1940.
- [39] Kull, K. (ed.), Special Issue on Jakob von Uexküll: A Paradigm for Biology and Semiotics. *Semiotica*, **134(1/4)**, De Gruyter: Berlin and New York, 2001.
- [40] Thom, R., *Stabilité structurelle et morphogenèse*, Interéditions: Paris, 1977.
- [41] Ruelle, D., *Hazard et Chaos*, Jacob: Paris, 1991.
- [42] Hoffmeyer, J., *Signs of Meaning in the Universe*, Indiana University Press: Bloomington, 1996.
- [43] Bateson, G., *Mind and Nature: A Necessary Unity*, Ballantine Books: New York, 1979.
- [44] Hoyle, F., *The Intelligent Universe*, Kindersley & Joseph: London, 1983.
- [45] Peat, D.F., *Syncronicity: The Bridge between Matter and Mind*, Bantam Books: New York, 1987.

- [46] Bohm, D. & Peat, D.F., *Science, Order and Creativity*, Bantam Books: New York, 1987.
- [47] Denton, M.J., *Nature's Destiny*, The Free Press: New York, London, Toronto, Singapore and Sydney, 1998.
- [48] Fondi, R., Armonistica: un ponte di collegamento tra la natura e la psiche. *Systema Naturae*, **1**, pp. 255–300, 1998.
- [49] Dallaporta-Xydias, N., *Scienza e metafisica. Uno pseudo contrasto tra due domini complementari*, Cedam: Padova, 1997.