RELATIONSHIPS BETWEEN SCIENTIFIC ANALYSIS AND THE WORLD VIEW OF PIERRE TEILHARD DE CHARDIN

by Lodovico Galleni

Abstract. This paper introduces the thought of Pierre Teilhard de Chardin from a perspective neglected until now: a view that builds on the analysis of his scientific papers. His scientific work formed part of the "modern synthesis" which laid the foundation of contemporary Darwinism. His main contributions in the field were the definition of a new branch of evolutionary sciences, geobiology; the redefinition of the term *orthogenesis;* and the proposal of the "scale" phyletic tree. Using these new research concepts, Teilhard de Chardin attempted to solve, within a scientific framework, a problem fundamental for his philosophical synthesis: that of evolutionary directionality.

Keywords: directionality; evolution; modern synthesis; Teilhard de Chardin.

The goal of this paper is to pursue the thought of Pierre Teilhard de Chardin from a largely neglected perspective: analysis of his scientific works. Much has been written about Teilhard's world view and his ideas on humanity's present and future from a theological, philosophical, or even political point of view. Too often, it is forgotten that Teilhard de Chardin was first of all a scientist, and in the fields of paleontology, anthropology, and geology, one of the most outstanding researchers of our century (Barjon and Leroy 1964; Piveteau 1964; Dodson 1984). In fact, the influence of his scientific corpus on the Teilhardian synthesis has been almost completely neglected. Yet, as Henri De Lubac (1962) wrote, Teilhard's work forms a unity as few works do, and the author's mark is recognizable throughout. According to De Lubac, it is also possible, first, to distinguish two phases of Teilhard's work (excluding the purely

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technical scientific writings). The first phase centers on scientific or philosophical reflections that begin with the experimental data. The second deals more specifically with mysticism and religion, and it often refers directly to the Christian revelation. Part of my work on the Teilhardian contributions seeks to demonstrate that even in "purely technical" scientific works (to use De Lubac's words) it is possible to find some relevant relationships to the rest of Teilhard's contributions.

TEILHARD DE CHARDIN'S SCIENTIFIC CORPUS

Teilhard's scientific work, particularly his evolutionary studies, may provide a new and useful introduction to the fundamental ideas of the Teilhardian synthesis. Some of Teilhard's publications were well known by the time he left for China (Teilhard de Chardin 1915, 1922); in fact, he was then considered one of the most outstanding French paleontologists. However, many of his most important articles were published in the thirties and forties during his Chinese period, when he was in isolation from the West, due to the unrest in China. They appeared in journals distributed in China during the Japanese invasion and during World War II. As a result, much of Teilhard's scientific work remained almost completely unknown for a long period of time.

Only recently Nicole and Karl Schmitz-Moormann (1971) have collected and republished the whole corpus of Teilhard's scientific works, thus providing a new and essential tool for scholars. For Teilhard's biography and the influence of scientific activity in his life we can refer to Cuenot (1958) and Lukas and Lukas (1977).

Teilhard's Chinese period was undoubtedly the most fruitful for his philosophy, and in this period he also participated in a series of important scientific projects: he made vast geologic investigations of almost completely unknown regions and continued the analysis of Chinese fossil fauna, in particular of mammals (Teilhard de Chardin 1942; Teilhard de Chardin and Leroy 1942, 1945a, 1945b). Moreover, he was a member of the research team that recovered and described the fossil remains of Peking Man, today called *Homo erectus pekinensis*. Teilhard helped analyze the remains, in particular by reconstructing the geologic strata where the fossils had been found and by analyzing the cultural artifacts (Black et al. 1933; Teilhard de Chardin 1941).

By the time Teilhard returned to Europe, he was well known among his fellow scientists throughout the world. In 1947 he took part in the Paris meeting on "Paleontologie et Transformisme"

(Teilhard de Chardin 1949). By this time, however, most of his energies were devoted to obtaining authorization to publish his philosophical works. All the attempts failed; not only that, he was once more forced to leave Europe. He found refuge in New York, where he died on Easter Day, 1955. All his philosophical works were published posthumously. Soon they surpassed in fame his scientific works, which in his lifetime had made him well known.

Actually, it appears that all Teilhard's scientific work was important primarily because of its contribution to his philosophical development: it opened to his thought the horizons of evolution. However, the various aspects of Teilhard's work remained separate and distinct. In reality the study of Teilhard's scientific corpus as a whole allows us to identify its fundamental influence on his philosophical endeavors. An attempt will be made here to analyze the main Teilhardian contributions to the study of biological evolution in the context of the evolutionary hypotheses of his time—and in relationship to his own ideas on mankind's present and future.

Beginning in the thirties, with his stay in China, Teilhard experienced an abrupt cultural change. In his former circles of French Catholicism and the French scientific and paleontological establishment, the prevailing attitude toward Darwinism was skeptical (Buican 1984). In the more cosmopolitan Peking culture, with its prevalence of English-speaking colleagues, the scientific environment was generally Darwinian. Furthermore, scientists in this circle were at that time arriving at the revision of Neo-Darwinism called "the modern synthesis" (Huxley 1942).

The effects of this cultural change are noticeable in Teilhard's work (Galleni 1982, 1984). In fact, he began to realize the importance of Darwinian mechanisms. In scientific papers written before his experience in China, he referred to hypotheses that tended to explain evolutionary mechanisms by placing both Lamarck and Darwin on the same level, without definitive choice in favor of one or the other.

> Though it is today indisputable that Lamarck, Darwin and their countless disciples in the nineteenth century saw a true light shining ahead of them, it is no less evident to us that, in the attempts they made to capture it many of their efforts went astray. (Teilhard de Chardin 1957; E.T. p. 7)

During the Chinese period, though, his scientific writings, at least, began to favor Darwinian mechanisms (Galleni 1982). His interest in research along these lines is clearly demonstrated by analysis of the journal *Geobiologia,* edited by Pierre Teilhard de Chardin in Peking from 1943 to 1945. The journal published book reviews along with original scientific papers. A good many of the books chosen for review by Teilhard and his friend and collaborator Pierre Leroy dealt with "modern synthesis" and its mechanism (Leroy 1943b; Teilhard de Chardin 1943b).

Darwinian thought had begun to create a problem because it maintained that evolution is the product of two independently interacting phenomena. The first phenomenon, mutation, is the cause of variability; in other words, mutation randomly provides the raw material for evolution. Natural selection then works on the variations, favoring the transmission from one generation to the next, within the same species, of those characteristics that provide superior reproductive success (Dobzhansky 1976).

From the theoretical point of view, this mechanism is fundamental. Lamarckism maintains that acquired characteristics are inherited. Thus the environment directly influences the organism, and therefore transformations are guided. The Darwinian hypothesis does not indicate any cause-effect relationship between mutation and selection, because mutations are random. On these bases, Darwin (1887) refused any interpretation of evolution based on a divine design.

Teilhard was aware of this fact when he gave one of the best definitions of Darwinian mechanism: "Life does not advance except when it is groping among the effects of large numbers and the game of chance" (Teilhard de Chardin, 1956b, 161; trans. for *Zygon* by Dorothy Walton). But in Teilhard's opinion there *was* something besides the scientific data: Teilhard was more than convinced that one evolutionary phenomenon involved the whole Universe, and that it had a precise goal. It represents the convergent path of matter towards more conscious forms. How could this vision be reconciled with the former one, inspired by Darwin's works and by the authors of the modern synthesis?

If the raw material of evolution is provided by random mechanisms, how is it possible to talk of matter moving towards consciousness, and therefore towards humanity, and of humanity moving towards God?

At least apparently, we are facing a blind alley where science and theology, physics and metaphysics seem to mix. Actually, the reciprocal influence of these fields became decidedly fruitful for Teilhard's work in general, including his scientific studies. The need to find the scientific basis for his concept of humanity's place in nature caused him to face the problem of directionality of evolutionary phenomena, within a scientific framework.

Therefore, it could be of interest to examine Teilhard's contribution to evolutionary theories and to what extent they match and partly integrate with those proposed by the authors of the modern synthesis. On the other hand, it is also important to examine the influence of his scientific contributions on the formation of his global vision of the past, present, and future of humanity.

From a chronological point of view, Pierre Teilhard de Chardin's contributions intersect and overlap. In this paper, however, they will be outlined according to a logical order:

1. geobiology
2. the redefinition of the term *orthogenesis*
3. scale phyletic trees

Teilhard's first important scientific works are paleontological; also, most of his publications during the Chinese period concern paleontology. Even today the papers of Teilhard and his coworkers are fundamental for the study of Chinese mammals (Zhou Ming Zhen 1981).

GEOBIOLOGY

Chardin and his collaborators, beginning with Pierre Leroy, perceived the pressing need of a new framework for organizing scientific data in order to reconstruct in a more detailed way the evolution of the main mammalian groups on which they were working. In order to go forward, they devised a new discipline, geobiology—he science of continental evolution. The goal of this new branch of biology was to examine together the development in time of certain phyletic branches (the field of paleontology) with the geographic dispersal of living forms (the field of biogeography), and to do all of this on a vast, continental scale.

Teilhard wrote:

> For a long time now, physicists and chemists have accepted the idea that inorganic terrestrial matter represents a natural whole whose elements, far from forming an accidental aggregation, express in their proportion and their arrangement a definite structure and composition, which is linked to both the atomic and the sidereal architecture of the universe. Hence, we have today achieved individualization of the physics and the chemistry of the Earth.
>
> Now the same trend becomes apparent in the realm of life, and it leads to the same results. On the one hand, the movement becomes more precise and accelerated (as I have just stated), which tends to make the biosphere rank among the most immense scientific realities we know about.
>
> And, on the other hand, correlatively to this, a place still unoccupied becomes visible on the forefront of science itself, a place for a discipline specially committed to the investigation of this biosphere.
>
> We already have geophysics and geochemistry. Now, to form a triad, enters geobiology. (Teilhard de Chardin 1943a, 2; trans. for *Zygon* by Karl Schmitz-Moormann)

And geobiology also becomes a part of his general view on the meaning of the universe, because it becomes a tool for the scientific investigation of the laws ruling the direction of evolution:

A convergent effort of all the sciences
1. to analyze the structure and the internal functioning of the biosphere; and simultaneously
2. to determine the structural and functional place occupied by the biosphere in the system of other planetary envelopes;
3. these two lines of approach will perhaps one day culminate in the discovery of a most general process, the process of constituting, on cold stars, ever more complex material units, from atoms to supermolecules, from supermolecules to cells, from free cells to metazoans and to social groups (wholes)—in this way one may conceive geobiology in its most general terms and gain its highest viewpoint. (Teilhard de Chardin, 1943a, 2-3; trans. for *Zygon* by Karl Schmitz-Moormann)

In the same issue of the journal, Pierre Leroy gave a more technical account of the aims of geobiology:

Through its methods, it will help biogeography by complementing its data. Provisionally limited to the study of life *of one continent,* it [geobiology] first learns its [the continent's] geology, creates lists of its fossil species, studies the succession of climates and the paleogeography. In the next step, geobiology tries to link the old faunas with the modern ones, to establish the connections, to know the factors of continuity that have favored one group or the other, to follow the evolution of species in one place or to find out about their migrations or disappearance.

Broadly speaking, geobiology is akin to biogeography, but it is distinguished from the latter because it adds to space the dimension of time and as well the idea of totality. Biogeography limits itself *practically* (not theoretically) to the living species; geobiology follows these same species as far as possible into the past; it studies their way of life and their adaptation to environmental changes. And furthermore, it tries to link their history to a unique process that has planetary magnitude. (Leroy 1943b, 13; trans. for *Zygon* by Karl Schmitz-Moormann)

In order to better develop the research in geobiology, Teilhard and his collaborators, during World War II, organized an Institute of Geobiology (Teilhard de Chardin et al. 1940). In five years' work at the institute, the geobiological method was applied to the phyletic analysis of developmental characteristics of many animal groups, mainly mammals, and fossil humans (Leroy 1940; Teilhard de Chardin 1941; Teilhard de Chardin and Leroy 1942; Teilhard de Chardin 1942; Teilhard de Chardin 1943c; Teilhard de Chardin and Pei Wen-Chung 1944; Teilhard de Chardin and Leroy 1945a; Teilhard de Chardin and Leroy 1945b).

In gauging the importance of the geobiological method in the whole of Teilhard's thought, the geobiological analysis of the phyletic evolution of the *Siphneidae,* small mole-rats of the Chinese Pleistocene, is particularly significant (Teilhard de Chardin 1942). Teilhard was able to reconstruct in good detail the temporal sequence of the main species that constituted the group over a 20-million-year period.

The part of the paper devoted to the *Siphneidae* (Teilhard de Chardin 1942, 33–81) provides a catalog of the fossil forms and a dichotomous classification of the fossil and living species together with a diagram showing the evolution of the family from its origin in the Miocene to the living species. This work later formed a basis for the geobiological map published by Pierre Leroy (Leroy 1943a, 15).

Among the papers of Teilhard, this study represents the best example of a geobiological analysis of a certain taxonomic unity. The group is well suited for this kind of analysis, and, as a matter of fact, Teilhard wrote:

> In most zoological groups the complex process of biological evolution is difficult to trace due to the excessive dimensions. If any particular group becomes too long-lasting in duration, too widely spread in geographical distribution, or too complex in composition, its various branches also become hopelessly mixed, or gaps begin to appear. In order to improve our knowledge of phylogeny we are greatly in need of discovering some animal groups that are long-lived and expanded enough to show internal differentiation, and yet sufficiently limited in time and space not to be obscured by emigrational depletion or immigrational complications.
>
> Quite exceptional, in this respect, are the *Siphneidae.*
>
> Owing to a lucky coincidence of geological, climatic and ecological factors (protracted and continuous deposition during the Late Cenozoic, over a wide and yet sharply limited area, of subarid soils where a fossorial form could thrive and become fossilized easily in limy concretions), the mole-rats represent an ideally rich and old, and, at the same time, ideally simple and closed animal unit. Strictly centered on a single focus of radiation, slow in their movements, rooted in the soil, and therefore closely confined in Northeast Asia, they represent a practically "pure" zoological pulsation.
>
> From this point of view, taken as a whole, they become just as useful and illuminating in the line of "Group-differentiation" and "Group-orthogenesis" as for instance the *Drosophila* fly does in the line of Heredity.
>
> Regarded at first as an odd and aberrant type of Asiatic rodents, the *Siphneidae* turn out to be a choice object for research, and perhaps the starting point for new methods of analysis, in the field of General Science. (Teilhard de Chardin 1942, 80)

The modernity and the scientific sharpness shown in Teilhard's words are evident when we consider that one of the most recent contributions to the study of evolution, the concept of punctuated equilibria, resulted from analysis of paleontological models of the type illustrated above (Eldredge and Gould 1972). In addition, this type of analysis has a significant impact on Teilhard's philosophy and leads to a discussion of Teilhard's second contribution to modern theories of evolution: redefinition of the term *orthogenesis*.

REDEFINITION OF *ORTHOGENESIS*

Orthogenesis, a term used mainly by paleontologists, denotes the cause of the directionality of evolutionary events. Because of its teleological overtones, the term became suspect to many evolutionists. Michael Ruse wrote:

> It was claimed that the fossil record showed certain non-adaptative trends, that sometimes certain features got larger and larger over the generations, and that although initially they may have had an adaptative value, towards the end, they can only have been a burden to their possessors. It was argued that if natural selection is really as powerful as its defenders suppose, such features could not have occurred. Such trends, the most popular examples of which were the teeth of the saber-toothed tiger and the horns of the Irish elk, were claimed to be the evidence of orthogenesis. This latter was supposed to be a kind of "force" or "momentum" which drove features beyond the point of maximum adaptative advantage. (Ruse 1969, 337)

Teilhard de Chardin was actually aware of the difficulties of the term and, in fact, he wrote:

> Whether or not—as I have just said—it is out of a spirit of imitation (or even of intimidation) in the face of the success of genetics, one thing is certainly clear: that in the last twenty years no self-respecting paleontologist has uttered the once classical word *orthogenesis* except with embarrassment or disdain.
>
> I am of course the first to recognize that particular meanings were originally attached to this term (as to the term *evolution*) which seem to us unacceptable today: an almost magical straightness of the phyletic lines, implying certain vitalist or finalist conceptions which are decidedly out of date.
>
> But there is a vast difference between correcting and rejecting. (Teilhard de Chardin 1957, 389; E.T. p. 270)

The paper on mole-rats is a good example of the emendation Teilhard intended for the term *orthogenesis*. In his description of the evolution of these creatures, Teilhard de Chardin (1942) found that the original peduncle of the *Siphneidae* soon divided into three branches that followed independent evolutionary lines. In all three there independently appeared similar traits: an increase in size, inception of continuous growth of the molars, and a fusion of the cervical vertebrae. He concluded that these changes provided directionality in evolution; to examples of this type, he applied the term *orthogenesis,* redefined as the appearance of similar characteristics in groups related but already separated. With this definition the term was free from any teleological or nonscientific meaning.

During a Paris colloquium, Paléontologie et Transformisme (Paleontology and Transformism), Teilhard de Chardin (1949) presented his analysis of the mole-rats as an example of directionality of evolution. The debate that followed his speech is informative. Among the participants were T. S. Westoll and G. G. Simpson, who underlined the fact that this case of parallel evolution could adequately be explained with the neo-Darwinian concepts of orthoselection. In fact, newly separated phyletic branches still have rather similar genetic inheritances. It should not be surprising, then, that these phyletic branches develop in a parallel way when they undergo similar selective pressures.

These comments offer another indication of the relationships between the neo-Darwinian modern synthesis and Teilhardian theories: Teilhard's orthogenesis may easily be explained through mechanisms of the modern synthesis (see also Dodson 1984). Increasingly, however, analysis of the developmental lines of evolution became Teilhard's favorite field of research: it allowed him to reintroduce a directional factor in the face of neo-Darwinian selectionists' emphasis on chance.

In his review of the French translation of G. G. Simpson's book *Rythme et modalite de l'evolution* (Rhythm and Modality of Evolution), Teilhard wrote:

> During his long career, Dr. Simpson stuck to his position, an intransigent neo-Darwinist attitude, as known to his friends. If one listened to him, everything in zoological evolution should be explicable by the play of selected chances *alone*. Besides the incontestable advantages of this attitude (which obliges the biologist to analyze and to take apart the mechanisms of morphogenesis), it has, we repeat once more, an evident weakness. In its obstinate refusal to look at the indisputable psychic ascent (invention) that globally accompanies the expansion and the arrangement of the biosphere, it deprives the evolutionary process of all direction and all significance as a whole, bringing about the particularly serious result of leaving the human phenomenon unexplained, and scientifically not understandable. (Teilhard de Chardin 1943b)

Teilhard's orthogenesis is, finally, the key to understanding the relationships between his scientific work and his theological and philosophical thought. Actually the concept of orthogenesis is used by Teilhard de Chardin at three different levels (Galleni 1981). The first level may be called *microorthogenesis* and may be defined as the appearance of similar characters in animal groups related but already separated, as in the mole-rats.

The second level of orthogenesis is, in my opinion, fundamental for understanding all the work of Teilhard de Chardin. It may be called *macroorthogenesis* and may be defined as the appearance of similar characteristics in widely separated phyletic branches. The most important example of this type of orthogenesis is cerebralization. Teilhard made a detailed analysis of species that clearly shows cerebralization in widely separated phyla. He reached his conclusions mainly from the patterns of evolution in vertebrates, but it is possible and interesting to extend this analysis to all the major animal phyla. An orthogenesis of cerebralization is clearly present in many metazoan phyla; not only in vertebrates but also in arthropods, mollusks, annelids, and also in such lower metazoans as flatworms. Patterns of evolution of these phyla seem to confirm Teilhard's hypothesis. But it may also be falsified: as a matter of fact, it is possible to find among metazoans some phyla (such as *Lophophorata, Pogonophora* or *Echinodermata*) that do not show any tendency to cerebralization.

Viewing cerebralization as a pattern of *macroorthogenesis* rationalizes the tendency of life, at least of animal life, toward cerebralization and consciousness. It is a scientific hypothesis because, as we have seen, it is based mainly on Teilhard's scientific data. But it is also the basic idea of all Teilhard's work. *Macroorthogenesis* of cerebralization is, according to Teilhard, a reflection of a more general tendency of universal evolution: the *complexity-consciousness law*—i.e., *megaorthogenesis,* the third level of evolutionary directionality. At this level of orthogenesis, matter shows a tendency toward organization in increasingly complex forms; once matter reaches a given level of organization (atom, molecule, macromolecule, cell, organism), it tends towards the next level, culminating with higher cerebralization and therefore with higher levels of consciousness (Teilhard de Chardin 1956c).

THE SCALE PHYLETIC TREE

We have arrived now at the point where Teilhard's philosophical and theological ideas overwhelm the scientific analysis. However, we have not yet examined Teilhard's third contribution to evolutionary theory. When viewed in the light of *microorthogenesis,* the phyletic trees used to reconstruct the evolution of an animal group do not have diverging trunks; instead, they form more or less evidently parallel scales. That is why, according to Teilhard, to reconstruct the evolution of a group means to identify the various scales that separated one from the other in time and to underline differences and divergencies, but also parallelisms between these scales.

> The discontinuity of the genealogical trees established by the Systematics is undeniable; and we have had the opportunity, many times already, in other studies, to analyze it in detail. Even our phyla which are the most successful (those of horses, rhinoceroses, elephants, camels, for example) seen from close up turn out to be formed not by one unique fiber, but composed of small overlapping segments, belonging to a very large number of lines which join each

other. At the origin of the phyla, the phenomenon is more pronounced. In the preceding pages, we have dwelt mostly on the natural groupings in sheets, whorls, and spokes which distinguish, in the mass of living beings, a biology understood as a simple science "of position." What we have not said until now (with the object of simplifying our explanation) is that these diverse units do not really form societies, as far as we know, unless one extends them ideally one into the other. More strongly nourished at their extremities, especially if these extremities themselves belong to the end of a branch which appeared more recently, the zoological branches shed their leaves, then they vanish quickly out of sight as soon as we try to redescend them to their point of attachment to a common trunk. The result is that the parts of the animal and vegetable world that are really known present themselves to us, as a whole and in their details, as tufts of leaves suspended in the air by certain invisible branches—or, again, to make another comparison, like those pinecones which have scales that touch each other while at the same time hiding their deep connections. (Teilhard de Chardin 1957, 75–76; trans. for *Zygon* by Dorothy Walton)

The scales diverge starting from a rather thin central stalk. I believe that Teilhard considered the stalk to be extremely thin, because he was aware of the findings of the authors of the modern synthesis. They maintained that microevolutionary mechanisms are essentially active at the population level, and, therefore, affect a rather limited number of individuals. The thin central stalk is the reason for the almost complete absence of transitional forms in the fossil record. A new group leaves a fossil record only when its numbers have become large. In turn, the numerical increase causes the formation of the scale.

Teilhard reconstructed the phyletic tree of human evolution using fossils found up to the forties and fifties. Teilhard published the most recent version in 1952, and a semischematic version appeared posthumously four years later (Teilhard de Chardin 1956a). In Teilhard's reconstruction, human evolution was, in some aspects, a case of parallel evolution. The australopithecines develop some tendencies characteristic of the other scales. With time the australopithecine brain and body tended to increase in size, and this characteristic is shared by all the branches and by the various scales of the human phyletic tree (Teilhard de Chardin 1956b, 215).

The *Homo sapiens* scale, though, is missing; its place is filled by a verticil. If the human species were like the other species, then at this point still other scales should form, and so on in a continuous, divergent process. However, something new occurred in human evolution that had never occurred in another animal group. With *Homo sapiens* a new step has been taken. The first step had been reached when matter passed from an inorganic form to life; the second step has now been reached, as life passes from a nonthinking to a thinking form: *Homo*. Something evolved that Teilhard calls reflective consciousness; the thinking sphere, the so-called noosphere, is also evolving. This fact has important consequences: if humans are able to think, the human heritage includes more than distribution of genes. It depends also on the capacity of humans to transmit their own thoughts. In other words, with human beings another factor comes into play in the evolution of life: cultural heritage. Teilhard affirms that from a Darwinian phase, which had characterized all prior evolution, humans proceed to a Lamarckian phase. It is now possible to talk of evolution of acquired characteristics because culture is passed on, not through genes, but through cultural heredity (Teilhard de Chardin 1959, 221). Furthermore, humans, uniquely among living species, can understand their evolution; and therefore they are able to guide and master it (Teilhard de Chardin 1956c).

Also, from the biological point of view, more exchanges between populations lead to increasing hybridization and consequently homogenization. With *Homo sapiens,* the human phyletic branch did not further subdivide into scales; instead, it developed what Teilhard calls inflorescence. The *Homo sapiens* inflorescence would not divide ever again but shows a strong convergent movement (Teilhard de Chardin 1955).

CONCLUSIONS

We have now arrived at the end of our discussion because at this point more and more philosophical, sociological, and theological reflections mix with the scientific data. According to Teilhard, other factors come into play at this point. He stresses (Teilhard de Chardin 1959) that humanity experienced an extremely important revolution when it moved from the hunting and gathering phase to the agricultural and livestock-raising phase: the Neolithic revolution. Beginning with the last two centuries, humanity has been facing another critical change: the industrial revolution. Before the industrial era, the possibility of exchanges between human populations hindered fragmentation of the inflorescence into various verticils. During the present era, humanity can not only exchange ideas easily, but also mix genes more readily. The inflorescence begins to converge on itself. This convergence is not merely physical but also cultural and spiritual. This tendency of human evolution cannot be opposed, but humanity can somehow guide it: the convergence of humanity has a goal that Teilhard called "the Omega point" (Teilhard de Chardin 1955).

It is impossible, in this kind of paper, which analyzes mainly the scientific work of Teilhard, to go further in the analyzis of "the

Omega point." This concept has in any case been widely analyzed by many authors (see Hale 1973). Briefly, Teilhard sees "the Omega point" as the moment when humanity, at the end of the evolutionary path, is ready for Christ's second coming.

In summary, the technical scientific reports of Father Teilhard are worthy of interest. They, in fact, strongly interact with the evolutionary hypotheses of the authors of the modern synthesis and, at the same time, they are fundamental to understanding Teilhard's ideas on humanity's present and future.

REFERENCES

Note: Numbers between brackets at the end of some references are those of the pages at which the papers are reported in Nicole Schmitz-Moormann and Karl Schmitz-Moormann, 1971.

Barjon, Louis, and Pierre Leroy. 1964. *La carrière scientifique de Pierre Teilhard de Chardin.* Monaco: Editions du Rocher.

Black, Davidson, Pierre Teilhard de Chardin, C. C. Young, and W. C. Pei. 1933. "Fossil Man in China. The Choukoutien Cave Deposits with a Synopsis of Our Present Knowledge of the Late Cenozoic in China." *Mem. Geol. Surv. China,* s.A 11:1-166. [1903-2080]

Buican, Denis. 1984. *Histoire de la génétique et de l'evolutionnisme en France.* Paris: Presses Universitaires de France.

Cuenot, Claude. 1958. *Pierre Teilhard de Chardin. Les grandes étapes de son évolution.* Paris: Librairie Plon.

Darwin, Charles. [1887] 1958. *The Autobiography of Charles Darwin.* Glasgow: Collins.

De Lubac, Henri. 1962. *La pensée religieuse du Père Teilhard de Chardin.* Paris: Aubier Montaigne.

Dobzhansky, Theodosius. 1976. "Teilhard de Chardin and the Orientation of Evolution. A Critical Essay." *Zygon: Journal of Religion and Science* 3 (September): 242-58.

Dodson, Edward G. 1984. *The Phenomenon of Man Revisited.* New York: Columbia Univ. Press.

Eldredge, Niels, and Stephen J. Gould. 1972. "Punctuated Equilibria: An Alternative to Phyletic Gradualism." In *Models in Paleobiology,* ed. T. J. M. Schopf. San Francisco: Freeman and Cooper.

Galleni, Lodovico. 1981. "Il contributo di Pierre Teilhard de Chardin alle moderne teorie evoluzionistiche." In *Teilhard de Chardin, Materia Evoluzione Speranza,* ed. A. Dall'Olio, L. Lombardo Radice, I. Mancini, and A. Santini. Rome: Edizioni Borla.

———. 1982. "P. Teilhard e il Darwinismo." *Il Futuro dell'Uomo* 9(3): 3-10.

———. 1984. "La Geobiologica, un contributo di Pierre Teilhard de Chardin allo studio dell'Evoluzione." *Il Futuro dell'Uomo* 11(1): 11-18.

Hale, Robert. 1973. *Christ and the Universe: Teilhard de Chardin and the Cosmos.* Chicago: Franciscan Herald Press.

Huxley, Julian S. 1942. *Evolution: The Modern Synthesis.* London: Allen and Unwin.

Leroy, Pierre. 1940. "The Late-Cenozoic Unionids of China." *Bull. Geol. Soc. China* 19:393-454.

———. 1943a. "Biogéographie et Géobiologie." *Geobiologia* 1:9-16. [3761-68]

———. 1943b. "The New Systematics According to Julian Huxley and Others." *Geobiologia* 1:129-38. [3883-92]

Lukas, Mary, and Ellen Lukas. 1977. *Teilhard, A Biography.* London: Collins.

Piveteau, Jean. 1964. *Le Père Teilhard de Chardin savant.* Paris: Fayard.

Ruse, Michael. 1969. "Confirmation and Falsification of Theories of Evolution." *Scientia* 104 s.VII:329-57.

Schmitz-Moormann, Nicole, and Karl Schmitz-Moormann. 1971. *Pierre Teilhard de Chardin, L'Oeuvre Scientifique.* Olten und Freiburg im Breisgau: Walter-Verlag.

Teilhard de Chardin, Pierre. 1915. "Les carnassiers des phosphorites du Quercy." *Ann. de Pal.* 9:101-92. [89-198]

———. 1922. "Les Mammifères de l'écocène inférieur francais et leurs gisements." *Ann. de Pal.* 10:169-76; 11:1-108. [253-385]

———. 1941. *Early Man in China.* Beijing: Institut de Géobiologie. [3261-3366]

———. 1942. "New Rodents of the Pliocene and Lower Pleistocene of North China." *Publications of the Institut de Géobiologie* 9:1-101. [3635-3746]

———. 1943a. "Géobiologie et Geobiologia." *Geobiologia* 1:1-8. [3753-60]

———. 1943b. "Quantitative Zoology According to Dr. G. G. Simpson." *Geobiologia* 1:139-41. [3893-95]

———. 1943c. *Fossil Men—Recent Discoveries and Present Problems.* Beijing: Henri Vetch. [3905-36]

———. 1945a. *Les Félidés de Chine.* Publications de l'Institut de Géobiologie 11. Beijing: Institut de Géobiologie. [4095-4158]

———. 1945b. *Les Mustélidés de Chine.* Publications de l'Institut de Géobiologie 12. Beijing: Institut de Géobiologie. [4161-4222]

———. 1949. "Sur un cas remarquable d'orthogénèse de groupe: L'évolution des Siphnéidés de Chine." In *Paléontologie et Transformisme. Rapports et discussions du colloque international de Paléontologie,* ed. J. Piveteau, 69-173. Paris: Albin Michel. [4276-80]

———. 1952. "On the Zoological Position and the Evolutionary Significance of Australopithecinae." *Transactions New York Acad. Sci.* 2 (14): 208-10. [4433-36]

———. 1955. *Le phénomène humain.* Paris: Editions du Seuil.

———. 1956a. "The Antiquity and World Expansion of Human Culture." In *Man's Role in Changing the Face of the Earth,* ed. W. L. Thomas, Jr. Chicago: Univ. of Chicago Press. [4580-89]

———. 1956b. *L'apparition de l'homme.* Paris: Editions du Seuil. Translated by J. Cohen, under the title *The Appearance of Man.* New York: Harper & Row.

———. 1956c. *Le groupe zoologique humain.* Paris: Albin Michel.

———. 1957. *La vision du passé.* Paris: Editions du Seuil. Translated by J. M. Cohen, under the title *The Vision of the Past.* New York: Harper and Row, 1966.

———. 1959. *L'avenir de l'homme.* Paris: Editions du Seuil.

Teilhard de Chardin, Pierre, and Pierre Leroy. 1942. *Chinese Fossil Mammals.* Publications de l'Institut de Géobiologie 8. Beijing: Institut de Géobiologie. [3491-3634]

Teilhard de Chardin, Pierre, Pierre Leroy, M. Trassaert, and J. Roi. 1940. *The Institute of Geo-Biology in Peking.* Beijing: Institut de Gébiologie. [3216-18]

Teilhard de Chardin, Pierre, and Pei Wen-Chung. 1944. *Le Néolithique de la Chine.* Publications de l'Institut de Géobiologie 10. Beijing: Institut de Géobiologie. [3937-4042]

Zhou Ming Zhen. 1981. "Teilhard de Chardin and Chinese Paleontology." Paper presented at the International UNESCO Symposium on the Occasion of the Centenary of the Birth of Teilhard de Chardin, Paris, September 1981.