Evolution of the Noösphere

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TEILHARD STUDIES is a monograph series concerned with the future of the human in the light of the writings of Teilhard de Chardin. Two issues each year are planned, to be sent to members of the Teilhard Association.

TEILHARD STUDIES

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With his wife and co-author Dianna L. Schulte McMenamin, he published *The Emergence of Animals: The Cambrian Breakthrough* (1990, Columbia) and *Hypersea: Life on Land* (1994, Columbia). Mark and Dianna have two children and are currently the pre-adoptive foster parents for a third.

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Mark A. S. McMenamin

I. Introduction

The origin and the emergence of the noösphere cannot be adequately discussed without reference to the most controversial subjects in the sciences. This is no coincidence—the subjects are controversial precisely because they are associated with the noösphere.

From its beginning, science has had two opposing schools of thought. The first saw the living world as having a design and thus a designer. The second saw life as a product of blind chance, without any ultimate goal or purpose.

The modern iteration of the debate[1] began when Pierre Teilhard de Chardin and George Gaylord Simpson engaged in a 1949 intellectual battle at the Paris "Colloquium on Paleontology and Transformism" (transformism being here synonymous with "evolutionary theory"). Teilhard began the debate by discussing cases of parallel evolution in myospalacine mole rats.[2] Teilhard's research into the evolution of these mole rats (genus *Myospalax*, Family Cricetidae [formerly Siphneidae]; Simpson 1953, Sukhov 1967) revealed that the main trunk of the myospalacine family tree diverged into three separate branches. These branches followed independent evolutionary trajectories. Similar traits then appeared in all three lineages. First, all animals experienced an increase in size. Second, each lineage developed continuous molar growth. Third, all evolved fusion of the cervical vertebrae.[3]

Teilhard argued that the example of the mole rats demonstrated directionality in evolution (Teilhard de Chardin 1942, 1950).[4] Implicit in this finding is the likelihood that all bodily features can evolve in similar ways in distinct types of organisms. Progressive increase in brain size, seen throughout the history of terrestrial vertebrates, was the type of directionality of most interest to Teilhard. Progressive change leads to Teilhard's Omega Point (McMenamin 1998, Barlow 1998a, Barlow 1998b).

Simpson's (1953, p. 246) response, that mole rat evolution is best interpreted as a response in similar animals to similar selective forces, was echoed by Teilhard scholar Edward O. Dodson in 1993 [p. 12]. Certainly any single example of convergence could be explained in this way. However, numerous examples of multiple convergence or parallel evolution have been described. Recall Teilhard's work with the myospalacine rodents, and consider further the discovery of the male dispersal morph in eusocial mole rats (eusociality had previously been known only in insects; see O'Riain et al. 1996). To this must now be added the following: development of poikilothermy in mole rats (Bennett et al. 1993, Buffenstein et al. 2001; an example of retrograde evolution in the direction of cold-bloodedness); convergences in feeding behavior (Burda et al. 1999) and acoustic communication (Credner et al. 1997); and acquisition of cellulose-digesting symbiotic microorganisms (Dyer, 1998; a convergence with termites). Such cases of stacked convergences strain the neodarwinian notion that evolution is purposeless, random, and ultimately devoid of direction. This in turn weakens the argument that evolutionary processes are inherently non-teological. Teilhard correctly realized that evolution is directed to an end or ends.

Hickman (1999) identifies Teilhard's view of evolution as ripe for renewed intellectual battle. Neodarwinist critics of *Garden of Ediacara* (McMenamin 1998) are slow to comprehend the intellectual sea change. In his review of *Garden of Ediacara* and its advocacy of neovitalism, Waggoner writes "Why [McMenamin's scheme is] different from the much less radical concept of evolutionary constraints, I'm not really sure." Baumiller [p. 40] writes "although unlike many vitalisms [McMenamin's] version invokes no mystical force to explain convergence and evolutionary progress, it fails to provide anything beyond the neodarwinian interplay among a 'shared genome' and 'environmental constraints' . . . . McMenamin's neovitalism is like 'the emperor's new clothes,' something that only he can see."

The materialistic worldview held by Hickman, Waggoner, and Baumiller is a classic example of Western scientific extrapolationism Vladimir Vernadsky warned us about (Vernadsky 1998; McMenamin 2000b). The aim of the section that follows is to identify the flaws in the materialist convention, and to urge my neodarwinian friends and colleagues to carefully consider the neovitalist position. The place to start is with analysis of an extinct group of organisms called Ediacarans (pronounced e-dee-ACK-ar-ins).

II. Metacells

> "When you go from monocellular to multicellular beings, some of the cells do behave in the same way as others, so subdivisions are defined." [Ilya Prigogine discussing Teilhard's work (p. 148 in T. King and J. Salmon, eds., *Teilhard and the Unity of Knowledge*, New York, Paulist, 1983)]

Ediacarans are a group of enigmatic, large (up to two meters in length) organisms that inhabited the sea floor for seventy million years beginning 600 million years ago. They went extinct (or nearly so) at 543 million years, curiously at the same moment that familiar types of animals (clams, snails, echinoderms, arthropods) emerged in an event known as the Cambrian explosion. Current theory holds that the Ediacarans were driven to extinction by the appearance of the first large and predatory animals (McMenamin and McMenamin 1990).

For decades a controversy has simmered over whether or not Ediacarans had descendants. Were they the ancestors of the Cambrian (and all subsequent) animals, or did they die out without issue? This problem is considered solved by those who believe that Ediacarans were not animals at all but rather a unique type of extinct marine creature. Ediacarans apparently had body complexity and large size that evolved independently of animalian-style multicellularity (McMenamin 1998).

Ediacarans grew to large size thanks to *metacellularity*—a comparatively loose aggregation of cells or compartments of cells (metacells or cell families). This is a comparatively "cheap" way for microbial creatures to grow large. When viewed as metacellular, Ediacarans may be seen to develop from one, two, three and up to as many as six metacells. This growth pattern "illustrates an evolutionary scenario involving nonproliferation as well as unipolar and bipolar proliferations of one to five independent cell families or lineages" (Hickman 1999; Buscalioni 1999). As put by Eagar (1998):

> In a modern animal, after the fertilized egg divides a few times to form the blastula, the cell divisions start going in all directions…if the division [were] highly directional, you would expect something like an Ediacaran.
>
> A one-directional development would produce something worm-like. In four directions, you get a creature shaped like a buttercup blossom—which indeed is a common form in the garden of Ediacara.

The metacellularity hypotheses gains further support by the recognition and correlation of "thumb structures" (stubby bifurcations of the founding cell families) between the bilaterally symmetric Ediacaran *Gehlingia* and the triradially symmetric Ediacaran *Tribrachidium* (Figure 1).

This growth pattern is quite unlike that seen in familiar types of large organisms. Some have suggested assigning Ediacarans to their own (extinct) kingdom, thus separating them from animals, plants, fungi, and everything else (Seilacher 1997). Others continue to advocate for an animalian interpretation of the Ediacarans, but this view is based either on weak arguments assuming Ediacarans to be animals (Dzik 1999; Lipps et al. 2000) or on misinterpretations of the fossil evidence (see criticisms raised in McMenamin 2000a).

III. Ediacaran Intelligence

In a 1993 article, Russian paleontologist Andrei Zhuravlev claimed that Ediacarans were unrelated to animals, and went so far as to advance the view that they were giant unicells. Zhuravlev's Figure 1 [p. 304] shows the classification of Ediacarans into a morphological series. In this table Zhuravlev refers to four Ediacaran genera *(Palaeoplatoda, Spriggina, Vendia,* and *Praecambridium)* as "cephalized." The quotation marks around "cephalized" are Zhuravlev's, indicating that he did not believe that unicells could have brains as do animals.

While agreeing with Zhuravlev that Ediacarans are not animals, I think that the apparent Ediacaran cephalization should be taken at face value, so to speak. In other words, these forms *were* undergoing cephalization. It is important to note that this development of brain occurred separately from the cephalization observed in the evolution of animals, and thus provides a case of convergent evolution.[5]

Ediacarans were apparently in the process of developing centralized sensory systems and nervous tissue or its functional equivalent, but from a metacellular rather than conventionally multicellular basis (Figure 2).

Figure 3 shows a sketch of the Ediacaran *Marywadea*. The fossil shows a nascent brain center on one end of the organism. Because of its metacellular growth pattern, *Marywadea* cannot be an animal, although its head structure is indeed eerily animal-like. It seems likely that Ediacarans such as *Marywadea* and *Praecambridium* were both undergoing evolutionary cephalization, that is, developing rudimentary intelligence. As would be expected, the cephalized forms of Ediacarans are the last to appear in their fossil record.

The development of the Ediacaran brain was the final development in Ediacaran evolution. As noted above, Ediacarans were driven to extinction by the appearance of brainy animal predators at 543 million years ago. In the parallel development of two types of mind, one type (animals) prevailed at the expense of the other (Ediacarans). Could it have gone the other way, had Ediacarans been able to develop an adequate means of defense[6]? The Ediacarans failed to do so, and so went extinct.

IV. Ediacarans and Complexification

Although we lack a complete understanding of the evolutionary process, Ediacarans give us key clues about the forces controlling this process. Neodarwinists agree with neovitalists that evolution shows a progressive character. But whereas neodarwinists see this progress as a function of evolutionary constraint, neovitalists see it as a result of Teilhardian complexification. There is common ground in the idea that "the universe naturally develops into animate complexity and its human phase" (Fabel 1998, p. 14). Ediacaran fossils are in accord with the naturalness (even inevitability) of this development. But are we really seeing a convergence of views in the idea that the universe is structured to evoke life and that life will eventually evoke mind?

Darwinists have great difficulty with this last statement, for, as put by Eagar (1998), "Teleology is about as bad a word as there is in Darwinism." Passions on this issue run high. Considerable effort is being expended to explain away cases of convergent evolution that appear to suggest evolution toward a common end (Bower 1999). The neodarwinian defense of a non-teleological model of evolution has been breached by ubiquitous examples of convergent evolution.

One may complain of the difficulty of measuring what Teilhard called "radial energy," but something very like it exerts control over evolution. In a world filled with examples of directed or convergent evolution, it would be fallacy to insist that there cannot in principle exist forces with the ability to, say, alter the probability structure of the universe. These alterations may even occur in a willful fashion (making them a particularly difficult subject for conventional scientific analysis).

One may cogently argue that certain complex forms of life (animals, Ediacarans) have the ability to tune in or amplify radial energy and its associated probability discontinuities. Some life forms resonate better than others. In contrast, biotic developments more akin to the growth of crystals (Hypersea; McMenamin and McMenamin, 1994) have been documented. With Hypersea, life follows the Vernadskian imperative ("the pressure of life," Vernadsky 1998) to spread, as Teilhard put it, its "frail but superactive film of highly complex, self-reproducing matter . . . around the world" (Teilhard de Chardin 1956; Fabel 1992). This amounts to a powerful diffusion of radial energy. If radial energy can be focused or concentrated (rather than being diffused), it will soon lead to singularities in space and time. As the universe approaches Teilhard's Omega Point, hints of radial energy might be expected to become more numerous in a world of tightening convergences.

Physicist Roger Penrose (Penrose 1995) has been criticized (Horgan 1996) for his suggestion that quantum fluctuations in nerve cell microtubules explain human consciousness. Penrose may not be right about the quantum microtubules, but his general perspective (that science has much to learn about the nature of consciousness) is the only honest stance to take at this juncture.

V. Circle of Convergence

> Do not let us pretend to alter the nature of things. It is neither possible nor useful to make the attempt; but accepting things as they are, let us strive to accord our minds with them.
>
> — Epictetus

> In this connection I once spoke of vitalism as a bridge connecting the normal with the field of psychical research.
>
> — Dreisch (*Psychical Research*, p. 116)

To the creationist, the theory of evolution represents a dangerous stockpile of devilish misinformation. To the Darwinist, evolution is the ultimate theory, the universal solvent that dissolves all in its wake. To one striving to accord one's mind to the nature of things, the study of evolution provides an intriguing opportunity to glimpse the mysterious forces that have shaped the noösphere, what Teilhard de Chardin called the "thinking stratum of the Earth."

The noösphere is associated with a powerful force that, in the words of Marais (1937), dominates all natural phenomena and directs them to some goal. Marais felt that the search for some powerful "group soul" above and beyond nature was something that perhaps could be studied but that it appeared a hopeless task to seek answers about the noösphere in nature.

> Every truthful naturalist, who is not led astray by his own hopes and longings, will always doubt his ability to give a truthful answer. It is possible that we see only a small arc of a gigantic circle, that the means and ways of the universal soul lie far beyond our human understanding. (p. 73-74)

It is now possible to sketch, in outline form, the perimeter of Marais' gigantic circle. This circle will be the central metaphor of the following section of this paper.

Our world contains much that for us is in principle unknowable. Like a great circle passing around a globe, however, I believe that sum of the knowable is like the intersection created by a plane passing through the sphere of all that is. By accident or (more likely) by design, the ring of what we can know forms a consistent and connected band of surpassing beauty and intense meaning. In my view, all human effort should be directed to grasping, if we can, this continuous halo of knowledge. This should not be approached as the vainglorious seizure of some kind of brass ring, but rather as a search for knowledge that will give us a sense of our true place in the universe.

It will not be easy to do this, because as noted by Marais, the complete view of the great circle is elusive. Darwinists are able to see one third of the circle, but the rest to them is hazy. Ultradarwinists deny that anything other than the clearly visible 120 degrees of arc actually exists. Creationists see a different arc with reasonable clarity, but refuse to see where it connects to the rest of the circle. The final third of the circle is ignored or ridiculed by purists in both the Darwinist and Creationist camps.

Paleontologists throughout the twentieth century recognized the dangers of the incomplete view. For example, Simon Conway Morris in his book *Crucible of Creation* is deeply troubled by the materialistic conclusions that might be drawn from *Crucible's* narrative. He counters these with allusions to Design and accountability, and asks how we may account for catastrophic lapses in "human values and decency." A similar question was posed to Teilhard in his 1947 debate with Gabriel Marcel. Teilhard was asked how he could remain optimistic about the future of man when confronted with the Nazi doctors of Dachau. Teilhard replied that after we have tried everything to its limit, we may begin to see the necessity of somehow "rising above" ourselves (Cuenot 1965). Conway Morris converges on a similar insight as he considers how our destructive acts (such as degradation of the biosphere to a "shadow of its former self") "may be redeemed."

Scientific research has made great strides in helping us to understand the ancestral relationships between major groups of animals. This knowledge must be placed in the context of·the great circle. It cannot be fully understood without this contextual support. We must be mindful that as we acquire an accurate outline of our history, we simultaneously assume enormous collective responsibility. Teilhard, again in response to Marcel, asserted that "to begin to know a thing in its entirety is to move from the material to the spiritual." Another way of saying this is that full knowledge of one arc requires extension of knowledge into arcs adjacent.

The three arcs of the gigantic circle are the evolutionary arc, the noöspheric arc and the spiritual arc (Figure 4). The first of these, the evolutionary arc, is primarily manifest as changes over time in organisms as a result of adaptations to their local environments. Life evolves because life is a special way of matter interacting with matter and energy. Although pretty much invisible to pre-scientific peoples, the evolutionary arc becomes vivid in all its austere beauty with the advent of historical earth science and evolutionary biology.

The noöspheric arc is to a great extent a continuation of the evolutionary arc. It can be described as a bridge between the evolutionary and spiritual and as a continuation of the evolutionary and spiritual arcs in, respectively, opposite directions. It can also be thought of as a force driving evolutionary change (Life-Force, elan vital or rationes seminales). Noöspheric forces can also be conceptualized as the attraction or pull between the spiritual and the material. Thus the noösphere is associated with progressive evolutionary change through time, leading many lineages to increases in bodily complexity and that ability to manipulate information about the environment we call intelligence. Knowledge of the evolutionary arc is a necessary but not sufficient condition for recognition of the noöspheric arc.

The noösphere is bursting with tractable (as well as many intractable) scientific problems, and this research is of supreme importance for helping us visualize the great circle. Evolutionary studies of convergence, at their best, lead us into the noösphere. Serious study of convergent evolution is in the early stages, but we already know that examples are found throughout all kingdoms of organisms.

The spiritual arc is both the most difficult and the easiest to see. Members of pre-scientific and even pre-literate societies were aware of its presence.

Modern purveyors of the numinous claim that the spiritual arc is readily apparent. This knowledge and insight had, almost by necessity, to be swept aside in order for the earlier stages of the scientific revolution to proceed. Gradual steps are accomplishing recovering the knowledge of this arc, and conditioning and restoring this knowledge for a world that has known science for several centuries. The veil is slowly being lifted from knowledge of this sort (see below). It is time to completely remove the veil masking the spiritual side of our world. Only by doing so are we able to comprehend the full circle.

Defining what is meant by the term "spiritual" is not an easy task, and most writers leave the term undefined and instead trust to the intuitive sense of their readers. Suffice it to say for now that that which is spiritual suffuses all things. Clear connections with the other arcs can be lost through disorder in the noösphere. The spiritual certainly represents a dynamic force: odd "coincidences" and miracles provide evidence that the spiritual arc influences the probability structure of the other arcs. Teilhard was certainly correct when he said, in reply again to Simpson, that humans can only be understood as evolutionary/noöspheric creatures with potential for conscious contact with the spiritual realm (Teilhard de Chardin 1943).

Knowledge of the spiritual arc has, like the rainbow, an ancient pedigree, whereas knowledge of the evolutionary arc is attributed to Charles Darwin. Discovery of the noöspheric arc is credited to Teilhard. The most interesting aspects of this model are the linkages between the three arcs. In science, the interfaces and boundary zones are the places where one usually finds the intellectual ferment. It is study of these interface zones that teaches us most about the nature of the full circle.

The study of animal evolution can be used as a departure point for investigation of the three arcs. Being animals ourselves we have an innate and intimate familiarity with animal life. Kingdom Animalia forms an exceptionally diverse group of quite closely related forms, ranging from bizarre cell-less glass sponges to trilobites to kangaroos. The animal genome is better understood than that of any other eukaryotic kingdom. Animals have, at least after the initial events, an evolutionary history that can be traced by means of fossil animal bodies and fossilized tracks and trails made by animals. The latter have the added benefit of providing clues to ancient animal behavior, and also provide what may be the most ancient evidence for paranormal phenomena as will be discussed in the next section. Finally, the serial and parallel evolution of animal consciousness is the most important example of convergence, for it led directly to emergence of the noösphere.

A good place to begin our analysis is near the boundary between the evolutionary and noöspheric arcs. In doing so, we will still be squarely on the evolutionary part of the gigantic circle, but will also consider evolutionary phenomena that give us clues to the workings of the noöspheric arc.

Consider a fish, a coiled cephalopod (such as an ammonite or nautiloid), a bat and a pterosaur. All four animals share a common ancestor, with the ammonite being the least closely related to the other three. All four creatures are able to fly, and I use the word fly in a very general sense to encompass self-propelled motion through a gas or liquid. Viewed this way, swimming is nothing more than flying through a liquid.

A primary requirement for any large organism moving through a gas or fluid is the ability to regulate its position. A typical fish accomplishes this by means of a swim bladder, a gas-filled internal organ derived, curiously enough, from the lungs in its Devonian ancestors. A coiled cephalopod such as an ammonite regulates its buoyancy with internal pockets of gas-filled space as well, but these gas chambers are derived from ancestral precursors that differ profoundly from those of the fishes' swim bladder. The gas-filled chambers in a nautilus shell developed initially as septate partitions at the pointed end of cap-shaped ancestral mollusk shells. These Cambrian mollusks became the ancestors of the ammonites and all other cephalopods such as the nautilus, squid and octopus (two shell-less forms).

Fish and cephalopods used the same tool, regulation of gas pressure in a sealed internal chamber, to perform the job of aquatic buoyancy regulation, but they acquired these tools by very different evolutionary pathways separated in time by over a hundred million years. Bats and pterosaurs also acquire their tools for flight at very different times, but the evolutionary origin of their wings are very similar. Both bats and pterosaurs (and of course birds as well) use the vertebrate paired forelimbs as organs of flight. The details of how the forelimb was transformed into a wing are not well understood. This much is clear; in each case the wing began as an organ for locomotion across a solid surface. The limbs in all three lineages share a common origin in a land dwelling reptile that walked on all fours.

Thus we see in fish, ammonite, bird, bat, and pterosaur a series of solutions to the problem of regulating one's position in air or water. I spoke recently to a group of secondary school students and one of them asked why a helium filled organism had not evolved in the air, using buoyancy for floating in air in the same way that fish and cephalopods use it in water. After praising the student for asking such an interesting question (had the student been reading Lois McMaster Bujold's 1996 book *Cordelia's Honor*?), I replied that I did not know why this had never happened. Perhaps such a gas bag organism would dry out too quickly or would have to be so comparatively flimsy that it could not go on about the ordinary tasks of life (feeding, defending itself against competitors, etc.) without risking undue damage. There are perhaps other reasons as well why a 'hot air balloon' creature might not be viable in an evolutionary sense. Or possibly this is a viable life strategy, but for unknown reasons no group of living organisms ever hit upon this particular solution to flying.

The point is that organisms over evolutionary time, through mutations, new combinations, function switches, symbioses and developmental changes will try out many different possibilities (if certainly not all conceivable possibilities) in the drive to survive and flourish. A successful innovation represents not just an individual success for an individual organism, but leads to the addition of an entirely new type of creature to the biosphere. This successful new organism will spread itself through its environment like a diffusing gas (Vernadsky 1998). Innovations represent solutions to the problems of life, and it should be no surprise that different organisms have solved problems in similar ways. Examples of convergence such as those emphasized above are extremely widespread throughout living nature and the fossil record. There is even a special type of convergent evolution called iterative evolution, in which a particular evolutionary character (flight for instance) is developed repeatedly over time in a sequence of organisms sharing both a common ancestor and a continuous source lineage.

These examples are all canonical instances of evolutionary change, and represent some of the most beautiful dimensions of the evolutionary arc. But how do they connect to the noöspheric arc?

Any organism that can feel an incentive (expressed as differential reproductive success) can be seen to evolve in a particular direction. Thus any type of evolutionary change that is associated with adaptation for improved survival can be considered a type of directional evolutionary change. Directional evolution, as we have seen, consists of organisms converging on a particular solution, with different solutions often beginning from very different starting points.

Development of intelligence, or ability to manipulate information about one's environment, is a biological stable attractor no different in principle from, say, the stable attractor of flight in air. Animals are seen to converge on higher and higher levels of intelligence through time in the same fashion that tree lineages grow taller over time as they struggle to reach more light and shade out the competition. Animals have become the most intelligent life forms living today. This does not mean that there is anything inherently special about animals, on the contrary it indicates that animals have shaded out other potentially intelligent forms of life by virtue of animalian success. Once intelligence in animals reached a particular threshold of behavioral complexity, it underwent an evolutionary transformation that led to an unusually diverse set of emergent properties.

The best known of these properties is the remarkable evolutionary diversification of animals at the beginning of the Paleozoic Era, an event known as the Cambrian explosion. But the most important property that emerges from animals crossing the intelligence threshold is the noöspheric arc. We can date its appearance to approximately 600-550 million years ago. The noösphere appears as a new type of information exchange in the biosphere. Before this time, organisms responded to light, temperature, chemical gradients, and the presence of other organisms as dynamic yet relatively predictable and tangible parts of their environmental surround. With the onset of the Cambrian, however, the rate of information exchange between organisms transformed the stable and tangible parts of the biosphere into an information flow that became unpredictable, even chaotic,[7] by virtue of the fact that it had become to a large extent disembodied. Consider a Cambrian predator with a brain and large, image-forming eyes. Consider further its search for prey. The prey organism, through a lack of camouflage, transmits to the predator a silent and unwitting signal that changes the activity of the predator and draws it in for the kill. Thus is established a potent and disembodied feedback system between predator and prey that completely overturned the marine biosphere in the early Cambrian. In a sense, the full circle (and Creation itself) was not complete until the birth of the noösphere, for it completed the circle by stretching a new arc between the evolutionary and the spiritual. The former had been in existence at least since the beginning of matter, and the latter had been in existence at least since the start of time.

VI. The Strange Case of *Vermiforma*

> The method of science in such a case is to stress all *verae causae* to the uttermost, and not to assume anything in the smallest degree supernormal unless all normal causes are carefully excluded.
>
> — Oliver Lodge, 1933, in forward to Driesch's *Psychical Research*

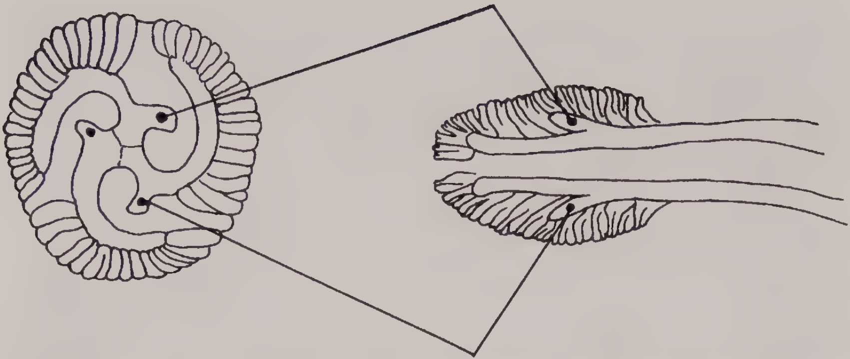

Figure 1. Comparison between the Ediacaran genera *Tribrachidium* (left; diameter l cm) and *Gehlingia* (right; length 5 cm). The two tie lines connect homologous structures (i.e., bodily structures sharing a common descent or ancestry) informally referred to as "thumb structures". This correlation indicates that these two Ediacarans are closely related in spite of their radically different (triradial versus bilaterally symmetric) body forms.

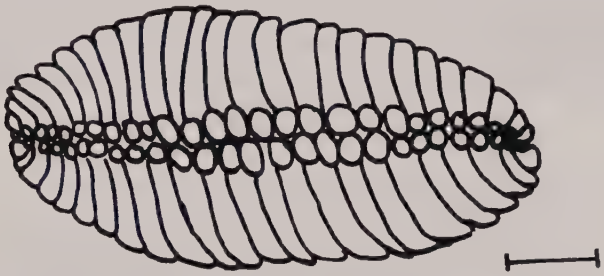

Figure 2. *Pteridinium carolinaensis* (St. Jean, 1973) recently discovered in Oakboro, North Carolina and now housed at the North Carolina Museum of Natural Sciences (Catalog Number NCSM 4033). This is an important specimen because, as a bipolar form with four iterating cell families (see McMenamin 1998), it provides evidence for the metacellularity theory of Ediacaran development. Scale bar 1 cm in length.

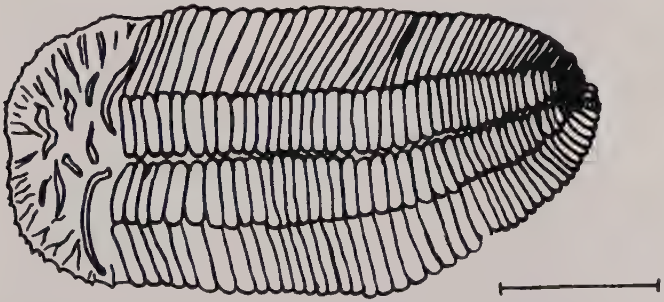

Figure 3. *Marywadea*, an Ediacaran from the Flinders Ranges of South Australia. The left end of this unipolar, iterating Ediacaran is interpreted here as a cluster of sensory structures organized into a rudimentary Ediacaran brain. Scale bar l cm in length.

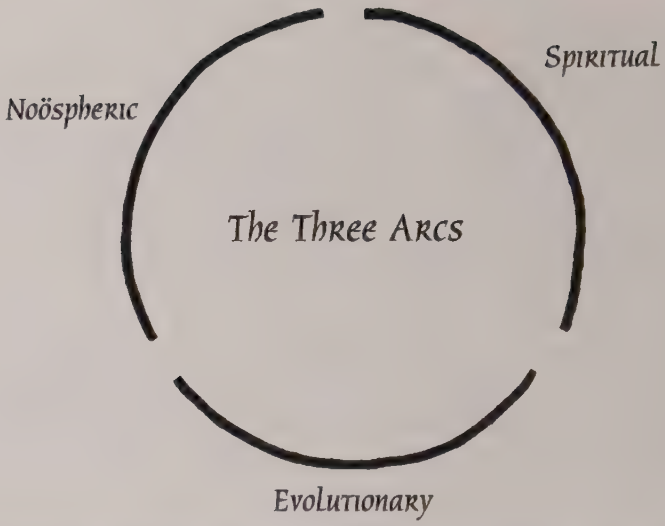

Figure 4. The three arcs of the gigantic circle: the evolutionary arc, the noöspheric arc and the spiritual arc.

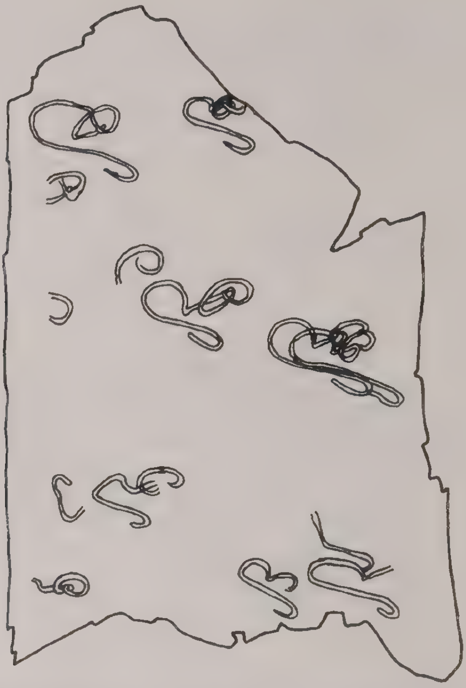

Figure 5. The *Vermiforma antiqua* slab reported in 1976 from the Carolina Slate belt. This diagram shows the unusual parallelism of the tracks. Width of slab 108 centimeters. Redrawn from Cloud et al. (1976) and Seilacher et al. (2000).

Figure 6. Photograph of *Vermiforma antiqua* slab. Pen for scale.

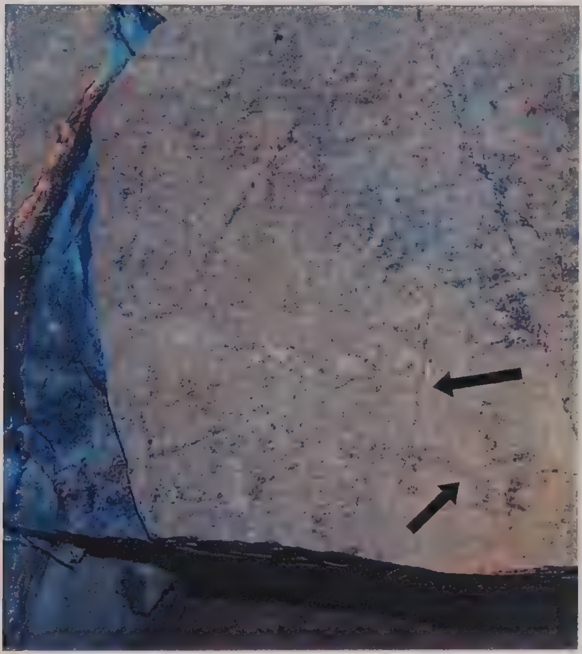

Figure 7. Metazoan burrow (upper arrow) associated with *Vermiforma antiqua* (lower arrow).

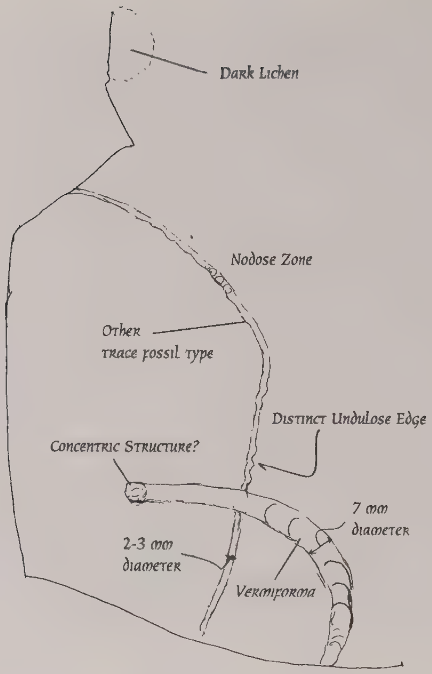

Figure 8. Freehand sketch of metazoan burrow associated with *Vermiforma antiqua.*

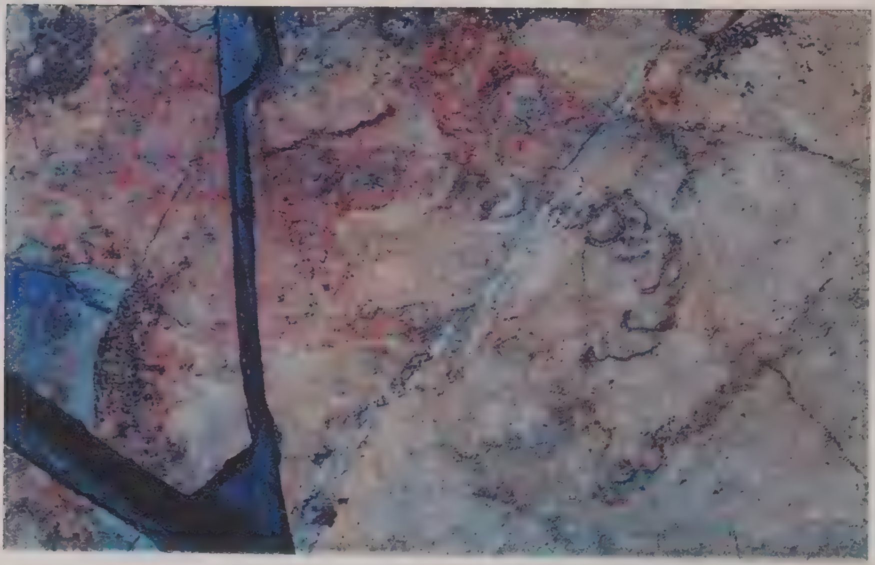

Figure 9. Image of *Vermiforma* (same as specimen 7, figure 10 of Cloud et al. 1976).

An enigmatic cluster of fossils from the Carolina Slate belt were reported in 1976 (Cloud et al. 1976), and were described as 620 million year old tubular worms (Figure 5). At the time of their description they were the oldest animal fossils known.[8] Cloud's putative body fossils were later reinterpreted as fossil burrows (trace fossils) rather than the body fossils of ancient worms (see references in McMenamin 1998).

The interpretation of *Vermiforma* is posing a considerable paleontological conundrum. Adequate discussion of *Vermiforma* will require some familiarity with the paleontological details of the case, and I will attempt to summarize these details as follows.

The *Vermiforma* structures have an unusual property not seen in other fossils. Each one of the traces has the same overall shape as the ten other traces on the ancient bedding plane surface. No two tracks are identical, yet each seems to mirror a shared track pattern. The pattern may be correlated from one track to the next. Cloud et al. (1976) had noted the repeated pattern, but it wasn't until the patterning was recognized as "quasiholographic" (McMenamin 1998) that the strangeness of these traces became evident. The pattern of each trace has been described as a sequence of a question mark, a kink, a second kink, and finally a pretzel-like coil (Seilacher et al. 2000).

Seilacher recently presented a clever reinterpretation of *Vermiforma*, arguing that it was actually a pseudofossil he calls a "tectograph" (Seilacher et al. 2000). In this view, pebbles rolling between two lithified beds of sediment formed the traces. As the beds slid (with a gyrating motion) back and forth along their shared bedding plane, the pebbles spun in approximate unison and inscribed the nearly similar tectograph patterns.

In spite of the ingeniousness of Seilacher's "rolling rock" explanation, doubts were quickly expressed about the validity of the tectograph model (Reed 2000). Hoping to get to the bottom of the controversy I visited the *Vermiforma* slab at the Smithsonian on July 12, 2000:

> *Vermiforma:* Preliminary observations: Slab has been broken up into ~14 pieces by settling. Wooden pallet on which it sits is in poor condition, broken and with nails sticking out....
>
> Fresh rock is grayish green classic Slate Belt fine Avalon[9] volcaniclastics.[10] Upper surface with *Vermiforma* is weathered to a depth of ~0.5 mm to a dark brown to limonitic tan. There is a 'cup-holder' shallow core [sample] taken out of one side of the upper surface....

> Not surprising that it's busted, it is an ungainly piece of rock. *Vermiforma* traces are distinct but do not seem to penetrate into the slab to any great depth.
>
> Slab is ~20-23 cm thick. Lower 15 cm show obvious soft sediment slumping features,[11] top ~5 cm well bedded, finely laminated. Top of slab has, in addition to *Vermiforma*, *Kinneya* structure[12] over much of its surface. A *Planolites*-like trail[13] occurs near the 'cup-holder'....
>
> The surface of the slab represents [an ancient] microbially bound surface. Mat strength was sufficient to form a protective film that stabilized sediment even during times of high local water velocity. Metazoan burrowers (undulose burrow) lived in the area, possibly feeding beneath the mats that were responsible for the *Kinneya* structure.
>
> The finely textured and well-preserved surface of this bed does not support a tectonic gliding [tectograph] hypothesis. The surface is essentially intact and has not been tectonized....I see now why Preston Cloud went to the trouble of excavating this enigmatic piece.

My observations of the *Vermiforma* slab falsify (at least to my satisfaction) the tectograph hypothesis. *Vermiforma* on the slab co-occurs with another type of animal trace fossil (Figures 7 and 8) as well as the microbial *Kinneya* structure. The second trace fossil type is intersected by *Vermiforma*. This second trace resembles the track made by a ballpoint pen writing across aluminum foil. The trace has undulose edges, giving the impression that the animal was engaged in peristaltic burrowing or was even spiraling as it moved through sediment. The nodose zone on this trace gives a faint impression resembling beads on a string.

It is possible that the animal that made the nodose track is the same creature that constructed *Vermiforma*. If so, the nodose trail represents the animal's locomotion trace and *Vermiforma* its deposit feeding trace.

It seems safe to conclude, since *Vermiforma* occurs on a virtually pristine bedding plane surface, that the bed has not been tectonically altered. We must now account for the track similarity between each *Vermiforma* specimen using a biological explanation. A repetitive programmed motion of foraging might be invoked to explain the similarities in trace shape, but would not account for why the traces are all oriented the same way (i.e., the longest stretches of the tracks all parallel). An explanation employing rheotaxis[14] combined with slow gliding over sediment on a slime track

(McMenamin 1998) is implausible because of difficulties described below.

By its restriction to a bedding plane known to host *Kinneya*, *Vermiforma* likely represents the track of an undermat miner that used microbial mats as a food source (Seilacher 2000). If this is the case, then rheotaxis (or other type of "taxis" involving direct contact with seawater) is out of the question as the burrowers lived *beneath* the sediment surface. How then are we to solve the problem of the nearly identical orientations of the North Carolina *Vermiforma* trace fossils?

Explanations involving synchronous dangling and dragging of some sort of trace-forming tether by either a floating microbial mat ("hyperscum"), or alternatively an ice rafting structure (e. g., Reid et al. 1999), seem even less plausible. The only way out for a conventional explanation of *Vermiforma* would be as a combination of programmed burrowing in an animal (needed to form the quasiholographic pattern) along with orientation of the organism in a continuously changing (or at least initially set) alignment with earth's magnetic field. Such combinations of burrowing behaviors, however, do not occur until much later in the Proterozoic and would not be expected in the very first animal trace fossils (see references in McMenamin and McMenamin 1990; McMenamin 1998).

While developing the rheotaxis hypothesis, I had argued (McMenamin 1998, p. 55) that:

> This quasiholographic repetition, in addition to overturning the body fossil interpretation, has not been described elsewhere in the fossil or sedimentary record and thus requires a special explanation, lest someone argue that the creatures were reading each other's minds.

Since *Vermiforma* is an animal trace fossil formed beneath a bacterial mat, and since the most ingenious conventional explanations for the pattern repeats have failed, we arrive at a most unusual scientific impass. We have no alternative but to consider the frightfully unconventional explanation that I had earlier tried to avoid.

It now appears time to boldly expand the list of multiple working hypotheses invoked to explain *Vermiforma*. We are required do so, as all of the plausible conventional explanations have been eliminated. How else to deal with a scientific anomaly of the first rank?

Let me preface what follows by saying that recourse to a paranormal explanation comes very unnaturally to a scientist trained in the Western scientific tradition, even one who holds devout religious convictions (as do I).

This class of explanation may be used only as a last resort and only after more conventional lines of investigation have been exhausted. This said, it now appears that the best explanation for the North Carolina *Vermiforma* congruent trackways involves one of the tracemakers controlling, via some kind of paranormal influence, the other conspecific organisms nearby. In other words, the *Vermiforma* tracks were directed by mind control at a distance, presumably by telepathic influence between the tracemakers.

The *Vermiforma* traces are among the oldest animal trace fossils known. If a paranormal interpretation for the pattern congruence is correct, distant nonlocal awareness was present early in animal evolution and may even be a foundational feature of animal constitution. It also implies that telepathy was latent in animal evolution (or at least absent from the fossil record) for over a half billion years (no other trace fossils showing *Vermiforma*-like congruencies are known). The paranormal re-emerges much later in the phenomenon of human consciousness and art (García-Rivera 2001).

VII. Emergence of the Noösphere

In recent decades some scientists have cautiously begun to consider paranormal explanations for anomalous phenomena. After a long hiatus in the publication of serious research on the subject (e.g., Dreisch 1933), the printing of Dean Radin's "The Conscious Universe: The Scientific Truth of Psychic Phenomena" (Radin 1997) is destined to be a major landmark on the path to acceptance of psychic phenomena. Radin makes a compelling case that such phenomena must be taken very seriously by scientists. Radin's case "rests on the strength of the scientific evidence, which stands on its own merits" (Radin 1997). Larry Dossey (2000) provides striking experimental evidence and discusses the clinical implications of nonlocal mind or what he calls "distant nonlocal awareness: a different kind of DNA."

Thanks to the emergence of this phenomenon, the conventional materialistic model of the universe collapses with a breathtaking finality. It seems difficult to conceive how something like precognition could fit into the standard model of physics, chemistry and biology; indeed, such difficulty helps to explain why scientists have been slow to accept the reality of paranormal phenomena. We know a good deal less about the world than we thought we did. There remains much to learn. Horgan's (1996) claim that science has ended needs to be inverted. Authentic science is just beginning.

Attempts to understand the noösphere as a metaphor for idea exchange, the Internet/Web, or the geological impact of humans (Vernadsky 1998) are misguided. The noösphere is present in the original, Teilhardian sense of the term. And whereas Vernadsky (reflecting his Lomonosovian uniformitarianism) saw life as having no beginning apart from matter and energy,[15] Teilhard saw it (or at least its noöspheric part) as having a transcendent and eternal character.[16]

Henri Bergson had a clear sense of this relationship between life and the noösphere. Only now can we begin to fully appreciate the depth of his vitalism. As Teilhard put it in a letter on April 3, 1930, "Ce que vous me dites de Bergson m'a profoundément ému. Je prie pour cet homme admirable que je vénère comme une espèce de saint.[17]" (Barthélemy-Madaule 1963).

Finally, the timeless debate between holders of the "Materialist view" and the "Religious view" has at last been settled in favor of the Religious. C. S. Lewis (1956, p. 20-21) argued with great insight that those who believe in Bergsonian "Life-Force philosophy" must be asked whether or not their Life-Force has a mind or will. If so, then Life-Force is really God, and their view is thus identical with the Religious. If not, vitalistic philosophy is absurd, for how can anything without mind strive or have a purpose?

As one might expect considering the sacred office of its creator, Teilhardian vitalism is profoudly religious. Even from a rationalist perspective, it is this version of neovitalism that appears to be the most correct of all philosophies. But one must be wary of conceptualizing Life-Force as a "sort of tame God. You can switch it on when you want, but it will not bother you. All the thrills of religion and none of the cost. Is the Life-Force the greatest achievement of wishful thinking the world has yet seen?" (Lewis 1956, p. 21).

Lewis' cautionary critique notwithstanding, we can now bring the analysis full circle with the following conclusions. A teological Life-Force, inherent to all matter, exists as a (if not the) motive force behind directed evolution. A noösphere is associated with the resultant organisms.[18] It is both an undeniable feature of reality and an expression of divine will.

NOTES

[1] I am not referring here to the so-called intelligent design theorists. Leonard Krishtalka of the University of Kansas Natural History Museum has referred to intellegent design theory as "creationism dressed in a cheap tuxedo." Philip E. Johnson, although correctly noting that some evolutionary theorists promote a secularized and materialist religion, still denies that an evolutionary process has taken place (Johnson 1994) and thus advocates an intellectually untenable position. Creationist interpretations of the stratigraphic record (e. g., Froede 2000) are dramatically at odds with sensible applications of sedimentary geology.

[2] All myospalacine mole rats (living and fossil) are now placed in the genus *Myospalax* Laxmann 1769 and are thought to be monophyletic and derived from primitive muroids (mice-like mammals).

[3] Interestingly, fusion of cervical vertebrae also occurs in marsupial "moles" belonging to the Notoryctidae ~(Nevo 1999).

[4] The paleontology of these late Miocene to recent mammals (Takai 1940) is apparently in need of revision, as some authors still place *Myospalax* in the Siphneidae (Zheng 1994), others in the Myospalacidae or Cricetidae, and still others in the Muridae (Lawrence 1991). Sukhov (1967) reduced the number of genera in the Myospalacidae to only two (*Prosiphneus* and *Myospalax*), arguing that other described genera were invalid as they merely represented growth stages of root development during molar growth. Even more recent work suggests placing all the myospalacine rodents in a single genus. This revision apparently does not impinge on the 1947 debate, as both Teilhard and Simpson agreed that Teilhard's three mole rat lineages had undergone convergent evolution. It would be of great historical interest to revisit Teilhard's data set and test his conclusions using modern methods of taxonomic analysis. Even should Teilhard's findings in this particular case be overturned, however, his general point about convergent evolution would remain valid, as many similar cases of convergent evolution have since been demonstrated in the fossil record; for example, parallel trends in graptolite evolution (Simpson 1953).

[5] This contention became the subject of a cover story in *New Scientist* (Daviss 1998), and has found its way into the British popular press (Oldfield 1998).

[6] For example, an electric shock or chemotoxin-based defense.

[7] This is not to say, as seems to concern Conway Morris (1998, p. 162-163), that the resultant ecological categories of the Cambrian (secondary

consumers, keystone predators, etc.) were unpredictable, only that the adaptive pathways by which organisms occupied these niches were chaotic. Ecological chaos would have contributed to the filling of niches by enhancing the rate of exploration of adaptive space. The rate of exploration was a function of ecological information exchange (McMenamin 1992, 1999).

[8] They still hold claim to the title of oldest fairly convincing animal fossils.

[9] Refers to the Avalon terrane, accreted to the northeastern edge of the North American continent by plate tectonic processes.

[10] Volcaniclastics are sedimentary rocks formed of fragments of volcanic rocks.

[11] Such features are formed by deformation of unhardened sediment as it slides down an underwater slope.

[12] *Kinneya* structures are unusual wrinkle features on bedding plane surfaces, widespread in Proterozoic sedimentary rocks, that are thought by most paleontologists to be the result of fossilization of bacterial mats.

[13] *Planolites* is a simple tubular borrow, among the most common type of trace fossil.

[14] Rheotaxis is orientation of an organism into a flow (water current or air stream) for the purpose of feeding, camouflage, etc.

[15] Vernadsky was harshly criticized for this view by Oparin (1938).

[16] The author wishes to thank T. M. Dykstra, A. Fabel, C. I. Martin, D. L. Schulte McMenamin, M. J. McMenamin, S. K. McMenamin, R. Nelson, M. O'Laughlin, P. Pflüger, A. Seilacher, S. Trembley and P. Weaver for timely discussion and assistance.

[17] "What you say to me of Bergson has left me profoundly moved. I pray for this admirable man and venerate him as a type of saint" [translation M. McMenamin, February 26. 2001].

[18] That is, once they have reached a particular level of complexity.

REFERENCES

Barlow, C. 1998a. Science update—rebirth of philosophical paleontology. *Epic of Evolution Quarterly* 2:30-31.

Barlow, C. 1998b. Teilhard and new developments in paleontology. *Teilhard Perspective* 31(2):1-2.

Barthélemy-Madaule, M. 1963. *Bergson et Teilhard de Chardin*. Éditions du Seuil, Paris.

Baumiller, T. 1999. A neovitalist view of evolution. *Complexity* 4(3):39–40.

Bennett, N. C., P. J. Taylor and G. H. Aguilar. 1993. Thermoregulation and metabolic acclimation in the Natal mole-rat (*Cryptomys hottentotus natalensis)* (Rodentia: Bathyergidae). *Zeitschrift für Säugetierkunde 58:362-367*.

Bergson, H. 1998. *Creative Evolution*. Dover Publications, Mineola, New York.

Bower, B. 1999. African fossils flesh out humanity's past. *Science News* 155:262.

Buffenstein, R., R. Woodley, C. Thomadakis, T. J. M. Daly and D. A. Gray. 2001. Cold-induced changes in thyroid function in a poikilothermic mammal, the naked mole-rat. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology* 280(1):R149-R155.

Bujold, L. M. 1996. *Cordelia's Honor*. Simon and Schuster, Riverdale, New York.

Burda, H., S. Begall, O. Grütje and A. Scharff. 1999. How to eat a carrot? Convergence in the feeding behavior of subterranean rodents. *Naturwissenschaften* 86:325-327.

Buscalioni, A. D. 1999. *Animales Fantásticos: La creación de un Reino hace mil millones de años*. Mundo Vivo/Libertarias, Madrid.

Cloud, P. E., J. Wright and L. Glover. 1976. Traces of animal life from 620 million-year-old rocks in North Carolina. *American Scientist* 64:396-406.

Conway Morris, S. 1998. *The Crucible of Creation*. Oxford University Press, Oxford.

Credner, S., H. Burda, and F. Ludescher. 1997. Acoustic communication underground: vocalization characteristics in subterranean social mole-rats (*Cryptomys* sp., Bathyergidae). *Journal of Comparative Physiology* 180:245-255.

Cuenot, C. 1965. *Teilhard de Chardin, A biographical study*. Burns and Oates, London.

Daviss, B. 1998. Cast out of Eden. *New Scientist* 158(2134):26-30.

Dodson, E. O. 1993. *The Teilhardian Synthesis, Lamarckism, and Orthogenesis*. Teilhard Studies Number 29.

Dossey, L. 2000. Distant nonlocal awareness: A different kind of DNA. *Alternative Therapies* 6(6):10-109.

Dreisch, H. 1933. *Psychical Research: The Science of the Super-normal*. G. Bell and Sons, London.

Dyer, B. D. 1998. A hypothesis about the significance of symbionts as a source of protein in the evolution of eusociality in naked mole rats. *Symbiosis* 24(3):369-383.

Dzik, J. 1999. Organic membranous skeleton of the Precambrian metazoans from Namibia. *Geology* 27:519-522.

Eagar, H. 1998. 'Garden' may contain world's oldest fossils [sic]. *The Maui News*, November 29, 1998, p. C5.

Fabel, A. 1992. Teilhard, Vernadsky and Gaia. *Teilhard Perspective* 25:1 June 1992, p. 6-8.

Fabel, A. 1998. *Teilhard 2000: The Vision of a Cosmic Genesis at the Millennium*. Teilhard Studies Number 36.

Froede, C. 2000. The pre-Flood/Flood boundary: scholarship and clarification. *Creation ex Nihilo Technical Journal* 14:63-68.

García-Rivera, A. 2001. Is beauty ancient history? *U.S. Catholic* 66(6):30-33

Hickman, C. S. 1999. Review of *The Garden of Ediacara* by M. McMenamin. *Systematic Biology* 48:224.

Horgan, J. 1996. *The End of Science*. Addison-Wesley, Reading, Massachusetts.

Johnson, P. E. 1994. Darwinism and theism, p. 42-49 in J. Buell and V. Hearn, eds., *Darwinism: Science or Philosophy?* Foundation for Thought and Ethics, Richardson, Texas.

Lawrence, M. A. 1991. A fossil *Myospalax* cranium (Rodentia: Maridae) from Shanxi, China, with observations on Zokor relationships. *Bulletin of the American Museum of Natural History* 206:261-286.

Lewis, C. S. 1956. *Mere Christianity*. Macmillan Company, New York.

Lipps, J. H., L. Gershwin and M. A. Fedonkin. 2000. Ediacara was no garden! *Geological Society of America Abstracts with Program*, v. 32, n. 7, p. A-300.

Marais, E. 1937. *The Soul of the White Ant*. Dodd, Mead and Company, New York.

McMenamin, M. A. S. 1992. The Cambrian Transition as a Time-Transgressive ecotone. *Geological Society of America Abstracts with Program* 24:62.

McMenamin, M. A. S. 1998. *The Garden of Ediacara: Discovering the First Complex Life*. Columbia University Press, New York.

McMenamin, M. A. S. 1999. The Cambrian Ecotone: Dynamics of a major evolutionary discontinuity. *Journal of Biospheric Science* 1(1):[www.mtholyoke.edu/courses/mmcmenam/journal.html].

McMenamin, M. A. S. 2000a. Out of the shadows. [Book review of Simon Conway Morris, *The Crucible of Creation: The Burgess Shale and the Rise of Animals*]. *Notes and Records of the Royal Society of London*, v. 54, n. 3., p. 407-408.

McMenamin, M. 2000b. The antiquity of life: From life's origin to the end of the Lipalian Period. Pp. 158-168. In: L. Margulis, C. Matthews, and A. Haselton, eds., *Environmental Evolution*, *Second Edition*. MIT Press, Cambridge, Massachusetts.

McMenamin, M. A. S. and D. L. S. McMenamin. 1990. *The Emergence of Animals: The Cambrian Breakthrough*. Columbia University Press, New York.

McMenamin, M. A. S. and D. L. S. McMenamin. 1994. *Hypersea: Life on Land*. Columbia University Press, New York.

Nevo, E. 1999. *Mosaic Evolution of Subterranean Mammals: Regression, Progression and Global Convergence*. Oxford University Press, Oxford.

O'Riain, M. J., J. V. M. Jarvis, and C. G. Faulkes. 1996. A dispersive morph in the naked mole-rat. *Nature*, v. 380, p. 619-621.

Oldfield, S. 1998. When Mr. Blobby's ancestor ruled the Earth. *Daily Mail*, May 14, 1998, p. 9.

Oparin, A. I. 1938. *The Origin of Life*. The Macmillan Company, New York.

Penrose, R. 1995. *Shadows of the Mind*. Vintage, London.

Radin, D. I., 1997. *The Conscious Universe: The Scientific Truth of Psychic Phenomena*. HarperEdge, New York.

Reed, C. 2000. Fossil signatures: Forged or real? *Geotimes*, v. 45, n. 5, p. 8.

Reid, J. B., E. P. Bucklin, M. Capozzi, L. Copenagle, J. Kidder, M. McCourt, S. M. Pack, P. Polissar, and C. Y. Spencer. 1999. Skating rocks at the Racetrack, Death Valley; what makes them move? *Eos* 75:275.

Seilacher, A. 1997. *Fossil Art*. Royal Tyrrell Museum of Palaeontology, Drumheller, Alberta, Canada.

Seilacher, A., M. Meschede, E. W. Bolton and H. Luginsland. 2000. Precambrian "fossil" *Vermiforma* is a tectograph. *Geology* 28: 235-238.

Simpson, G. G. 1953. *The Major Features of Evolution*. Simon and Schuster, New York.

Sukhov, V. P. 1967. Nakhodka ostatkov kornezubykh tsokorov roda *Prosiphneus* (Rodentia, Mammalia) v Bashkiorskom Predural'ye I nekotoryye voprosy sistematiki semeystva Myospalacidae. [Fossil mole-rats with rooted molars of the genus *Prosiphneus* [Rodentia, Mammalia] in the Ural foreland of Bashkiria, and some systematic problems of the family Myospalacidae]. *Doklady Akademii Nauk SSSR* 177(3):695-698.

Teilhard de Chardin, P. 1942. New rodents of the Pliocene and lower Pleistocene of China. Pub. Inst. Geobiol. Pekin, No. 9.

Teilhard de Chardin, P. 1943. Quantitative zoology according to Dr. G. G. Simpson. *Geobiologia* 1:139-141.

Teilhard de Chardin, P. 1950. Sur un cas remarquable d'orthogénèse de groupe: l'évolution de siphnéidés de Chine. *Colloques Internat. Centre Nat. Rech. Sci.* 21:169-173.

Teilhard de Chardin, P. 1956. The antiquity and world expansion of human culture, in W. Thomas, ed., *Man's Role in Changing the Face of the Earth*. University of Chicago Press, Chicago.

Vernadsky, V. 1998. *The Biosphere*. Complete annotated edition. Copernicus, New York.

Waggoner, B. 1999. Review of McMenamin, M. A. S., 1998, *The Garden of Ediacara: Discovering the First Complex Life*, Columbia University Press, New York. *Palaeontologia Electronica*, 15 March 1999.

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39. Dupuy, Kenneth E., *The Once and Future Earth.* Spring 2000

40. Rae, Eleanor, *Divine Wisdom: Her Significance for Today.* Summer 2000

41. Greene, Herman F., *Understanding Thomas Berry's Great Work* Autumn 2000

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McCulloch, Winifred, *A Short History of the American Teilhard Association.* 1979.

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American Teilhard Association

THE AMERICAN TEILHARD ASSOCIATION is dedicated to these objectives:

1. A future worthy of the planet Earth in the full splendor of its evolutionary emergence.
2. A future worthy of the human community as the high expression and fulfillment of the earth's evolutionary process.
3. A future worthy of the generations that will succeed us.

Guided by the writings of Pierre Teilhard de Chardin, the Association seeks to bring an encompassing perspective to this great task of shaping the well-being of the entire earth community at a time when so many crises threaten it. Teilhard's vision of the sequential evolution of the universe from its origin to the human phenomenon, can provide a firm and inspiring basis upon which to proceed. Now for the first time, humanity is converging to a new unity in diversity that needs to be understood and facilitated. To help in this work, the Association, since its foundation in 1967, has sponsored annual conferences, a monthly lecture series, study groups, and a variety of publications.

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> *"Love is the free and imaginative outpouring of the Spirit over all unexplored paths."*
>
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