BOOK REVIEWS

A. Lima-de-Faria, *Evolution Without Selection Form and Function by Autoevolution*. Elsevier, Amsterdam, New York, Oxford 1988, 372 pp., hardback U.S. $ 168.50

There are a few valid points in A. Lima-de-Faria's *Evolution Without Selection Form and Function by Autoevolution* but unfortunately they are embedded in the far-fetched examples, illogical progressions and disjointed lists with which the author attempts to demonstrate that evolution occurs not by natural selection but by autoevolution. Lima-de-Faria's major problem with natural selection seems to be that it is not Popperian enough. The term is abstract and the concept is impossible to prove with a controlled scientific experiment; as Lima-de-Faria states it 'Selection cannot be weighed or poured into a vial. As such it is not a component of the mechanism of evolution' (pp. 7, 312). This is a good example of the type of *non sequitur* that is abundant in this book, in that weighability and pourability are not criteria that come to mind when evaluating theories, nor is autoevolution itself especially weighable or pourable. Lima-de-Faria's point is certainly valid when he says that natural selection has 'no way of predicting the emergence of new species' and 'no laws, expressed in mathematical terms, that describe the interrelationships occurring in the evolutionary process' (p. 311). A multi-variable biological theory is not likely to fit the mold of a simple theory of physics. A comparison of the wonderfully predictive and mathematical 'F=MA' with the cumbersome 'natural selection' is like comparing apples and orange groves with orange groves consisting of the trees plus all of the microorganisms, animals, and plants with their many levels of interaction. On the other hand Lima-de-Faria rejects some of the simpler experimental or natural systems that are used to demonstrate natural selection, such as the selection of pesticide-resistant mosquitoes, the selection of antibiotic-resistant bacteria, the selection of milk over-producing cows, etc. He re-interprets some of this type of example such as 'When cells in culture are treated with drugs, resistant lines can be obtained' and manages to cite from the literature an exceptional example (Alt *et al.*, 1978 *J. Biol. Chem.* 253:1357-70) in which the drug methotrexate induced a stepped increase in dihydrofolate reductase in cultured mouse cells which turned out to be due to an amplification of genes for this enzyme. Thus Lima-de-Faria manages to avoid the words 'variability' and 'selection' and is able to demonstrate that this is 'directed mutation' 'determined by a change in the outer environment' (pp. 260–261).

The book displays many photographic plates (Figures 3.7–3.11, 9.8–9.26, 10.6–10.7, and 10.15–10.18) to demonstrate the striking visual analogies between animals, plants, and minerals. This is one of the strangest and most unconvincing aspects of the book. Figure 3.8 depicts objects with leaf-like patterns: pure, native bismuth, a poison ivy leaf, and two leaf-like invertebrate wings (which some people might call examples of mimicry of leaves by insects). Figure 3.10 shows an example of

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pure, native silver with curved, protruding crystals. It also shows the fruit of a plant featuring curved tendrils and finally the curved tusks of an extinct mammoth. Lima-de-Faria attributes these and many other examples to 'canalization'.

A list on page 106 titled 'What does animal-mineral isomorphism mean?' continues the canalization theme and includes such pairs as water crystals and bird feathers, native gold and animal skeletons, and 'magnetic-kerosene' and 'circumvolutions of human brain'. Explanations follow the list (p. 110). The water crystal-bird feather connection represents 'a process of the simple addition of molecules in air to an original nucleus'. Native gold and skeletal parts are 'connected with the free addition of atoms in air and that of free molecules in the embryonic liquid'. The magnetite-kerosene and brain connection actually has two references cited for it. Frankel *et al.* (1979 *Science* 203:1355–6) have found bacteria which orient in Earth's magnetic field by means of magnetic particles, and Walcott *et al.* (1979 *Science* 205:1027–8) have found magnetite in the skulls of pigeons which enables them to orient themselves during migration. These two facts are presented by Lima-de-Faria as quite sufficient to convince the reader that his juxtapositions (also shown in Figure 9.17) are valid. Figure 9.17 begins with an interesting maze-like pattern which may be obtained by mixing 'magnetic liquid' and kerosene and subjecting it to a magnetic field. Also shown are a histological cross section of a mushroom, and a human brain, all presenting the same maze-like pattern. This phenomenon is attributed on page 112 to a 'mineral ancestry' or to the 'minero-type' which later assumes the form of genotype in plants and animals'.

A section on 'monsters' (pp. 35–36) seems oddly anthropocentric and the term 'monster' is never clearly defined. The logic here goes something like this: Monsters are always 'violent and nasty' but animals are not; monsters which are 'random and evil' constructions are never seen in nature therefore nature is not random, but ordered.

Throughout the book, relatively simple observations about natural selection have ether been rearranged slightly or have had certain words substituted resulting in new meanings. For example (p. 70) 'The increase in the [atmospheric] oxygen results in the emergence of a new chemical factor conditioning the evolution of both animals and plants' such as changes in 'ventilation'. It is not clear what is meant by 'ventilation' here but it could just as well be stated that the increase in oxygen concentration selected for those animals and plants which (due to natural variability) had particular ventilation systems. Chapters 19 and 20 continue with numerous examples of 'modifications caused by physical agents...' or 'by chemical agents'. Many of the examples seem to be attributable to entraining, or physiological conditioning, or developmental regulation. Tucked into this section is one interesting and seemingly valid point that animals in warmer water have DNA richer in G and C than animals in colder water, probably due to greater thermal stability of GC rich sequences. Thus one could conclude that 'temperature appeared as a major factor in the canalization of the evolution of DNA', but I find it challenging to conclude that '...the relationship between temperature and the color phenotype of animals can now be better understood due to the fact that is has been discovered recently that temperature actually changes the genotype of higher organisms' (p. 234). Bernardi and Bernardi (1986 *J. Mol. Evol.* 24:1–11) whose work is cited in this section might be surprised at this interpretation considering that in their paper they state 'mutations are fixed mainly through natural selection' and that the G-C phenomenon is an example of natural selection of a genome-level phenotype. Bernardi and Bernardi are cited at least one other time as evidence that: 'mutation is an ordered process' (p. 263) and another paper (Botstein and Shortte 1985 *Science* 229:1193–1201) is also cited for this statement, although the actual topic of this paper is gene-targeting strategies used in genetic engineering.

Other examples of altered vocabulary are in Chapter 16, in which Lima-de-Faria manages to avoid the word 'homeostasis' but refers to the counteraction of 'the physical and chemical agents of the outer environment' (p. 203). In Chapter 21 (pp. 242–243) Lima-de-Faria seems baffled by gene regulation and prefers to coin a term 'gene erasing' to explain (for example) how *Ranunculus* (water lilies) might have linear leaves underwater, broad-floating leaves at the air-water interface and an intermediate form, when all are derived from the same genotype. The phenomenon is further explained (pp. 272, 276) with a bizarre analogy. Snow flakes produced in air with high water-vapor content have a lacier shape than those thicker snow flake crystals produced in dry air. Likewise with the filamentous, underwater leaves of *Ranunculus* and the broader leaves at the air-water interface, states Lima-de-Faria, however, it is quite the opposite in birds in which the aquatic foot is broad and webbed in contrast with the aerial foot. He concludes 'The change of the shape in relation to water may not be an adaptation, but just like in the case of the plants or the snow crystals, a change of pattern that is determined by the concentration of water that surrounds the cells. This happens irrespective of what consequences it may have for the animal or plant'. Not only is it difficult to follow the logic in this example but the only reference on snow flakes cited for this section actually presents a reasonable explanation for lacy snow crystals (Knight and Knight 1973 *Scientific American 228*:100–7). That is, since snow crystals are made of water, they tend to grow more quickly in an atmosphere high in water-vapor. The rapid growth manifests itself in elongate, dendritic crystals. Duck feet and water lilies would seem to be only remotely and superficially connected to this phenomenon. Also there is nothing particularly predictable or mathematical about Lima-de-Faria's hypothesis (assuming these to be desirable criteria).

Readers of books on evolution are usually familiar with the giraffe example, often presented as a contrast between Lamarckian and Darwinian evolution. Here is a new twist (pp. 269–270). The giraffe neck is not an 'adaptation created by selection' but is 'the product of the independent evolutions of the different molecular complexes of the organism which followed their own channels irrespective of the consequences they would have for organismal phenotype'. The giraffe neck is there 'because the minerals of the cell, the base group of DNA or the phospholipids of the membranes happened to change their chemical interactions'. To give Lima-de-Faria some credit here, it is a valid point that organismal evolution is really at the mercy of the physical constraints of the environment and the limitation of the raw materials (such as hydrocarbons) but he does seem to carry this to an illogical extreme by making this the central concept of this theory. On page 270 he states, 'The biological level itself becomes a prisoner of the cycle of interactions restablished between protein, DNA, and RNA. This further narrowed down the number of alterations and obliged the cell to represent certain pathways irrespective of the prevailing circumstances'. I could actually accept a statement like that if I did not have to apply it examples like the snow flake, water lily, bird foot one, and many other equally difficult examples throughout the book.

A technique of establishing an opponent (natural selelction) with clay feet is frequently used such as when Lima-de-Faria points out that even after a long evolution, photosynthesis still remains a very inefficient process (1–2% of solar energy is recovered by cultivated plants). This inefficiency supposedly contradicts 'One of the basic tenets of neo-Darwinis ...that, given time and selection, any type of adaptation can be obtained'. I do not believe that any neo-Darwinist would claim that much greater efficiency will *necessarily* be attained within the projected life span of Earth as we know it. On page 287 Lima-de-Faria states 'The gene does not create form or function' and as quoted in the paragraph above the giraffe neck is not an 'adaptation created by selection'. The word 'create' seems unnecessarily vague and would seem to set up natural selection for easy contradiction. Furthermore, its use suggests either a deliberate or unintentional misunderstanding of genes and natural selection.

A 'mineral-gene collaboration' is presented as instrumental in the formation of shapes and a role for DNA as, if anything, minor. 'The gene product only intervenes by being incorporated into the mineral structure in the form of an organic matrix (1% in the skeletons of sea urchins)'. 'The gene only makes a minor adjustment by intercalating its product into the mineral structure' p. 287. The word 'minor' here is up for interpretation. It is true, that given a particular set of chemical conditions, the precipitation of calcium carbonate is inevitable and perhaps even unstoppable. However it is not obvious to me that the *shape* of the sea urchin shell is a *minor* adjustment in the life of the sea urchin considering that the alternative is a mass of amorphous calcium carbonate.

The book concludes with a chapter (26) on ethics and sociobiology in which autoevolution is featured (and about which I will not comment), and two chapters (28 and 29) which are entirely in list format. These two were quite difficult to read as the sequence of 56 items (in Chapter 28) and 75 items (in Chapter 29) was in no particular order that I could follow. The Chapter 29 list is actually a compare and contrast table of Darwinism and autoevolution, in which autoevolution presents itself as a rather reactive theory. For example, Item 4 states that a central tenet of Darwinism and neo-Darwinism is 'Selection directing the origin of life', and for autoevolution 'Selection has nothing to do with physics or chemistry'. Not only are the two items not parallel either conceptually or grammatically but it is a fallacy in logic to assume that refuting one theory proves another.

This is certainly not a main stream book on evolution and seems to be somewhat out-of-character for Elsevier. If there is a reason to order this expensive book for your college or university library, it may be that it would be interesting for students of the philosophy of science who are examining questions like 'What is a scientific theory?' and 'What is needed to prove one?' *Evolution Without Selection Form and Function by Autoevolution* is full of examples that will instigate (at least) discussion and comments.

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Christopher G. Langton (ed.) *Artificial Life*, Santa Fe Institute: Studies in the Sciences of Complexity Vol. VI. Addison-Wesley Publ. Co., Inc. Redwood City, Cal. 1989. pp. 688, 10 color plates; hardback $ 43.25, paper $ 21.50.

What is artificial life? The proceedings of the first workshop on 'Artificial Life' held at Los Alamos in September 1987 try to give an answer. This collection of 24 articles written by 33 authors is by no means the documentation of a well defined and homogeneous subject. Contributions of very different, mostly interdisciplinary areas are brought together and show the vague contours of a potential new field of research. Almost all chapters are fascinating, nevertheless, and many of them provide insight into the beauty of computer games conceived by powerful intellect.

The editor contributes a preface which contains an informative summary of the book and an introductory chapter reviewing the history of concepts in artificial life. He presents also his understanding of the subject and surveys the current state of the art. Two other papers by Laing and Pattee deal with the history and the definition of artificial life as well.

Models for the origin of life are introduced in three contributions by Rasmussen, Tamayo and Hartmann as well as Zeleny, Klir and Hufford. They illustrate different issues of the problems: dynamics of autocatalytic reaction networks, reaction-diffusion systems modelled by cellular automata and a 'synthetic biology' based on osmotic growth. Four papers deal with different aspects of evolution. Packard addresses the role of the environment as a part of the evolving system. Wilson introduces genetic algorithms which mimic some features of evolution on the computer. Moravec views the history of human culture as a genetic takeover still going on. Dawkins presents a computer model based on genotype-phenotype dichotomy in which embryological morphogenesis itself is considered as a phenotypic trait.

Beautiful color plates contain among other things the results of computer models on plant development by means of Lindenmayer's L-systems and the artificial menagerie of Oppenheimer. The theoretical background of the impressive pictures is given in two articles by Lindenmayer and Prusinkiewicz and by Oppenheimer. Four other papers deal also with computer simulation systems useful for modelling various aspects of life. Ecosystems are studies in two articles by Taylor, Jefferson, Turner and Goldman and by Hogeweg. Goel and Thompson present a tool for modelling molecular self-organisation, in particular virus self-assembly. Lugowski's model is related to molecular dynamics but treats also higher-level issues.

The paper by Morris introduces 'typogenetics', a molecular logic of genetic operations on DNA. The following papers leave the close neighborhood to actual life. Resnick presents a computer version for building objects from the LEGO toolkit. Coderre analyses data flow trees by means of techniques from artificial intelligence. Travers introduces a system simulating the behavior of synthetic artificial animals.

A new fascinating topic called 'nanotechnology' applies mechanical technology to objects on the molecular level. It is treated in two papers by Schneiker and Drexler. Aspects of the cellular cytoskeleton – one of the keys for an understanding of the subtle relations between cellular metabolism, control of cell division and development of organs – are modelled by Hameroff, Rasmussen and Mansson. The last paper by Braitenberg finally introduces the extremely difficult and fascinating field of movement control of arms and legs.

A very useful annotated bibliography is added at the end of the book.

The editor presents a collection of interesting articles on various systems which share some properties with living beings. Coming back to the initial question, we may conclude that there is a common feature which the different models share and which might serve as a hint towards a definition of artificial life: the rules of the game are defined on a low hierarchical level of local or individual interactions, whereas unexpectedly complex global features develop in executing the programs. Still, many challenges remain, among them the problem where to draw the borderline between artifcial life and artificial intelligence.

The book can be recommended to everybody who enjoys the beauty of complexity in nature and likes its images in computer games.

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H. E. LeGrand, *Drifting Continents and Shifting Theories: The Modern Revolution in Geology and Scientific Change*. Cambridge University Press, Cambridge 1988, 313 pp., cloth $ 16.95.

This is a book on science history and science philosophy. More specifically it treats the paradigm change in geological sciences that started before World War I and was completed about twenty years ago. This process was started by Alfred Wegener, who in 1912 proposed that all the continents had once been united, had broken apart, and had drifted through the ocean floor to their current locations. He called this model 'Continental Drift'. You need not have a particular background in geology in order to find the book interesting; in fact, if you read it you will probably be awarded with better knowledge of the scientific basis of modern Earth Sciences than many geologists have. The subject of this scientific thriller is the takeover by the modern Plate Tectonics theory from the previous models of how the Earth's crust and continents are constructed and change with time. The author gathers the different varieties and precursors of the modern Plate Tectonics theory into one single and convenient term: 'the Drift'. This collective term refers to global theories that invoke large-scale lateral displacements of the crust as a central geological process.

In several ways the theoretical basis of Earth Sciences some fifty years ago very much resembles that of the Origin of Life Sciences today. No consensus of one single theory of the Earth's crustal development existed, instead 'theoretical pluralism' prevailed. There were Permanentists and Contractionists, like in Origin of Life Sciences there are the 'Proteins-first' and 'Nucleotides-first' camps. A couple of decades before 'the Drift theory' had conquered Earth Sciences this scientific field was even enriched by a group of Expansionists and their model. The parallel to Origin of Life Sciences and the addition of the 'Clays-first' camp is almost too obvious. Who knows, maybe also the Origin of Life Sciences society will find that some fourth, yet unknown (?), different theory is generally accepted by the beginning of the next century.

LeGrand touches upon several scientific problems of general importance. For instance, what if scientists take opposing views of the very aims of their discipline? In Earth Sciences, as an example, different tradition exists between 'Survey Geologists' and 'University Geologists'; or between the North American school and the European school. Geology was in North America always considered a descriptive science, whereas in Europe it has been more freely used for explanatory purposes. Global theorizing without firm geological evidence has a long and respectable tradition in Europe, particularly in Germany. This is probably the main reason why the scientific confrontations, especially across the Atlantic, concerning 'the Drift' for a long period were so harsh – often even hostile. As the author remarks the new view of the Earth was revolutionary because it was a global theory in the dual sense of being a whole-earth theory and a theory which drew upon and drew together all fields of the science. One effect of this new view was the increasing importance of geophysics and geochemistry within classical geology. This, in turn, meant that researchers with backgrounds in physics or chemistry and who were oriented towards theory rather than to descriptive field work were attracted into the discipline. The use of geophysics and geochemistry generated pressure for stronger basal knowledge of mathematics, physics and chemistry in geological training. The effect was that the old descriptive historical science of Geology was transformed into a predictive casual Earth Science, and that specialities that were previously central to the science, like paleontology, were moved to the periphery. The overall result was a change of geology as a historical science toward geology as an explanatory science.

LeGrand points to the creation of an intellectual trap by going from theoretical pluralism to theoretical conformism. Modern textbooks in geology give the impression that no pluralism in global theories exists; that there is no alternative to the 'Plate Tectonics' theory; and that no other, less widely-shared programs continue to exist. This is described by LeGrand as indoctrination into the dominant program. During the 'pre-Drift' days it was common for textbook authors to give summaries of rival programs and the arguments and evidence that were used in the debate for and against each program.

At the end of each chapter there is a section that the author calls 'Voice-Overs'. These sections are helpful inventions where an amateur reader is guided by LeGrand through science philosophy; where consistencies and compatibilities between different theories are discussed; and where the contents of the chapter is even more elucidated and commented upon. The instructive 'Voice-Overs' are one reason why the book may be of such general interest to most scientists. At the end of the last chapter LeGrand asks the question: 'How much of what we have learned can be applied to the growth of other sciences?' The only way you can find out is to read his book.

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