"Nothing in Biology Makes Sense Except in the Light of Evolution"
——Theodosius Dobzhansky[1]

Universal Aspects of Biological Evolution?[2]

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Abstract: Which biological laws, if any, might be universal?

As working hypotheses, astronomers and astrophysicists expect that the laws of physics and chemistry, as we understand them, and based on observations and experiments on and near Earth, apply throughout the galaxy and the universe. To what extent this expectation is tested by experiments and observations is a subject of continuing debate. Many astronomical observations can be interpreted as supporting these hypotheses, but they might break down in extreme conditions that are not similar to what can be achieved in Earth-based observations and experiments.

At least to the extent that biological laws are emergent from physics and chemistry, we might expect that there are also biological laws, as we understand them, that hold throughout the Galaxy and the Universe. An obvious candidate for such universal biology is Darwinian evolution through mutation (and recombination) and natural (and artificial) selection and including also sexual reproduction, speciation, inter- and intra-specific competition, predation, parasitism, and symbiosis. This geomorphism, like anthropomorphism, is sometimes justifiable, sometimes just wrong. But some of the arguments for some of the laws of biology are, if correct, then universal.

In this brief note, there is time to try to sell only one or two quick ideas. I would like to convince you that: (1) A *level-of-development* parameter can be defined for Earth's biosphere in terms of total usable information contents in genes in genomes and memes in brains and extrasomatic memories such as libraries and magnetic disks. The concept of *progress* can then be defined as an increase in this level-of-development.[4] (2) Earth's fossil record shows that unsteady progress has occurred. (3) Even after Darwin and the modern synthesis of Darwinian theory and modern genetics, we really don't understand *why*. But (4) we can approach the problem by considering the differential survival of information *replicators*, that is genes and memes. And (5) a reasonable extrapolation of the trend predicts continued progress for Earth's biosystem and presumably also for other biosystems and civilizations elsewhere.

Even a cursory examination of Earth's fossil record firmly establishes the phenomena of evolution. From no fossils in the oldest rocks through single-celled organisms, then wigglers, eaters, creepers, crawlers, swimmers, runners, fliers, thinkers, up through the

evolutionary sequence—more species, more diversity, more complexity: four-and-a-half billion years of *un*steady progress. Even if a fuzzily defined concept, there is overwhelming evidence for something happening that we label *progress*.

The phenomena of progress are well-known; the explanation is not. We don't understand very well the origin and evolution of life on Earth, and we don't know whether extraterrestrial life is common or exceptional in the universe in part because we don't have a theory to apply to such phenomena. Darwin himself and many modern evolutionists repeatedly emphasize that natural selection predicts local adaptation and evolution but not global progress. No theory does.

What biology is all about, I would argue, is the differential survival of potentially immortal replicators called genes and memes. These replicators are, strictly, a category of information, rather than, for example, DNA, RNA, or paper, which are *media* on which replicators are written or by which replicators are propagated. These information replicators are typically *instructions* for doing or making things, such as the behavior and morphology of organisms. A successful replicator is one that somehow promotes its own survival and replication in the prevailing environment, or sometimes, manages to alter the environment to promote its own perpetuation. The metaphor of purpose—genes and memes function as if their only (teleonomic) purpose were to propagate and perpetuate themselves—is a rarely deceptive and often powerful way of thinking. Since the differential survival of these information replicators is so fundamental, I suggest it as a good (maybe the best) candidate for universal biology.

Genes are units of information usually stored in the nuclei of cells; memes are units of information sometimes in brains, sometimes in books. An archetypical meme is a *recipe*, say, for baking a cake. A recipe can exist in mind or on paper or both. Recipes are pleiotropic memes (many memes are pleiotropic) with two phenotypic effects or meme products: baking (behavior) and cake (artifact). In most cases, the cake is the desired product; the baking is undesirable in the sense that if the cake could be obtained some other way, then the time, effort, and materials needed for the baking would be saved for some other use. This is not to deny that some people enjoy baking; but how long would they continue to bake if no cakes or inedible cakes resulted?

Suppose a baker uses a recipe to bake a cake. If he likes the cake, he keeps the recipe, uses it again when he wants another cake, and maybe shares cake and recipe with relatives and friends. (Unlike cake, you can have your memes and share them too.) If he doesn't like the cake, he discards the recipe, marks it "no good," or at least modifies

(recombines or mutates) it before trying again. If, however, the cake is accidentally damaged, say because the oven failed (a conculinal defect), the recipe is unaffected unless the baker doesn't realize what happened; he might throw out the recipe inappropriately. This process is closely analogous to artificial (genetic) selection of domesticated plants and animals. Memes and genes follow very similar rules of evolution.

A strong analogy exists between genes and memes, and many of the well-known ideas about genetic evolution can be translated into memetic language.[5] Genetic evolution and cultural evolution are two aspects of the same problem, *but* we don't really understand either aspect.

What is needed is a *unified general theory* that contains dissipative structures in non-equilibrium thermodynamics (Prigogine), the origin of life and biology from non-living material, evolution by mutation and natural selection of replicators (Darwin), information theory (Shannon), chaos theory (Feigenbaum, Mandelbrot), theory of complex systems (Kauffman), and progress through accumulation of information in hierarchical structures up through civilizations, all as special cases or corollaries.

Such a unified general theory would be concerned with instruction, a category of information, and will probably define a level-of-development parameter proportional to the logarithm of the instruction content (in bits) of a system but accounting for redundancy: Two copies of the same instructions are worth only a few bits more than one copy. Progress is defined as an increase, stagnation as no change, and regression as a decrease in this level-of-development parameter. Then we need to try to specify the conditions under which progress is certain, likely, unlikely, or impossible.

On Earth, these instructions reside in genes, brains, and extrasomatic memories such as libraries and computer disks. Geological and archeological history of Earth shows 4.5×10^9 years of *un*steady progress. Reasonable extrapolation predicts future progress for ourselves and presumably also for other comparably old civilizations.

If such a unified general theory is emergent from physics and chemistry, then it presumably applies throughout the universe.

Alas to say, such a unified general theory will need to be written by someone cleverer than I.

References and Notes[6]

1. (Quote is title of article) Dobzhansky, T. *The American Biology Teacher* 35:125 (March 1973).

2. Presented at the Institute on Religion in an Age of Science (IRAS) conference, 2006 July 29 to August 05 at Star Island, New Hampshire. Revised: 2006 August 13.

3. John Ball is an epistemologist-arrant who works as a radio astronomer at MIT Haystack Observatory in Westford, Massachusetts.

4. See Ball, John A., "Extraterrestrial Intelligence: Where is Everybody?" *American Scientist* **68(6)**:656 (1980).

5. See Ball, John A., "Memes as Replicators," *Ethology and Sociobiology* **5(3)**:145 (1984).

6. This note is a revised and updated version of Ball, John A., "Universal Aspects of Biological Evolution," p. 251 in *The Search for Extraterrestrial Life: Recent developments*, M.D. Papagiannis (ed.), International Astronomical Union (1985).