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Evolution's Thermodynamic Failure

By [Granville Sewell](#)

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In the current debate over "Intelligent Design," the strongest argument offered by opponents of design is this: we have scientific explanations for most everything else in Nature, what is special about evolution? The layman understands quite well that explaining the appearance of human brains is a very different sort of problem from finding the causes of earthquakes; however, to express this difference in terms a scientist can understand requires a discussion of the second law of thermodynamics.

The first formulations of the second law were all about heat: a quantity called thermal "entropy" was defined to measure the randomness, or disorder, associated with a temperature distribution, and it was shown that in an isolated system this entropy always increases, or at least never decreases, as the temperature becomes more and more randomly (more uniformly) distributed. If we define thermal "order" to be the opposite (negative) of thermal entropy, we can say that the thermal order can never increase in a closed (isolated) system. However, it was soon realized that other types of order can be defined which also never increase in a closed system. For example, we can define a "carbon order" associated with the distribution of carbon diffusing in a solid, using the same equations, and through an identical analysis show that this order also continually decreases, in a closed system. With time, the second law came to be interpreted more and more generally, and today most discussions of the second law in physics textbooks offer examples of entropy increases (order decreases) which have nothing to do with heat conduction or diffusion, such as the shattering of a wine glass or the demolition of a building.

It is a well-known prediction of the second law that, in a closed system, every type of order is unstable and must eventually decrease, as everything tends toward more probable (more random) states. Not only will carbon and temperature distributions become more disordered (more uniform), but the performance of all electronic devices will deteriorate, not improve. Natural forces, such as corrosion, erosion, fire and explosions, do not create order, they destroy it. The second law is all about probability, it uses probability at the microscopic level to predict macroscopic change: the reason carbon distributes itself more and more uniformly in an insulated solid is, that is what the laws of probability predict when diffusion alone is operative.

The reason natural forces may turn a spaceship, or a TV set, or a computer into a pile of rubble but not vice-versa is also probability: of all the possible arrangements atoms could take, only a very small percentage could fly to the moon and back, or receive pictures and sound from the other side of the Earth, or add, subtract, multiply and divide real numbers with high accuracy.

The discovery that life on Earth developed through evolutionary "steps," coupled with the observation that mutations and natural selection -- like other natural forces -- can cause (minor) change, is widely accepted in the scientific world as proof that natural selection -- alone among all natural forces -- can create order out of disorder, and even design human brains with human consciousness. Only the layman seems to see the problem with this logic. In a recent *Mathematical Intelligencer* article ("A Mathematician's View of Evolution," 22, number 4, 5-7, 2000), after outlining the specific reasons why it is not reasonable to attribute the major steps in the development of life to natural selection, I asserted that the idea that the four fundamental forces of physics alone could rearrange the fundamental particles of nature into spaceships, nuclear power plants, and computers, connected to laser printers, CRTs, keyboards and the Internet, appears to violate the second law of thermodynamics in a spectacular way.

Anyone who has made such an argument is familiar with the standard reply: the Earth is an open system, it receives energy from the sun, and order can increase in an open system, as long as it is "compensated" somehow by a comparable or greater decrease outside the system. S. Angrist and L. Hepler, for example, in *Order and Chaos* (Basic Books, 1967), write, "In a certain sense the development of civilization may appear contradictory to the second law.... Even though society can effect local reductions in entropy, the general and universal trend of entropy increase easily swamps the anomalous but important efforts of civilized man. Each localized, man-made or machine-made entropy decrease is accompanied by a greater increase in entropy of the surroundings, thereby maintaining the required increase in total entropy."

According to this reasoning, then, the second law does not prevent scrap metal from reorganizing itself into a computer in one room, as long as two computers in the next room are rusting into scrap metal -- and the door is open. In Appendix D of my new book, *The Numerical Solution of Ordinary and Partial Differential Equations*, second edition, (John Wiley & Sons, 2005) I take a closer look at the equation for entropy change, which applies not only to thermal entropy but also to the entropy associated with anything else that diffuses, and show that it does not simply say that order cannot increase in a closed system. It also says that in an open system, order cannot increase faster than it is imported through the boundary. According to this equation, the thermal order in an open system can decrease in two different ways -- it can be converted to disorder, or it can be exported through the boundary. It can increase in only one way: by importation through the boundary. Similarly, the increase in "carbon order" in an open system cannot be greater than the carbon order imported through the boundary, and the increase in "chromium order" cannot be greater than the chromium order imported through the boundary, and so on.

In these simple examples, I assumed nothing but heat conduction or diffusion was going on, but for more general situations, I offered the tautology that "*if an increase in order is extremely improbable when a system is closed, it is still extremely improbable when the system is open, unless something is entering which makes it **not** extremely improbable.*" The fact that order is disappearing in the next room does not make it any easier for computers to appear in our room -- unless this order

is disappearing **into** our room, and then only if it is a type of order that makes the appearance of computers not extremely improbable, for example, computers. Importing thermal order will make the temperature distribution less random, and importing carbon order will make the carbon distribution less random, but neither makes the formation of computers more probable.

What happens in a closed system depends on the initial conditions; what happens in an open system depends on the boundary conditions as well. As I wrote in "Can ANYTHING Happen in an Open System?" (*The Mathematical Intelligencer* 23, number 4, 8-10, 2001), "order can increase in an open system, not because the laws of probability are suspended when the door is open, but simply because order may walk in through the door.... If we found evidence that DNA, auto parts, computer chips, and books entered through the Earth's atmosphere at some time in the past, then perhaps the appearance of humans, cars, computers, and encyclopedias on a previously barren planet could be explained without postulating a violation of the second law here (it would have been violated somewhere else!). But if all we see entering is radiation and meteorite fragments, it seems clear that what is entering through the boundary cannot explain the increase in order observed here."

THE EVOLUTIONIST, therefore, cannot avoid the question of probability by saying that anything can happen in an open system, he is finally forced to argue that it only seems extremely improbable, but really isn't, that atoms would rearrange themselves into spaceships and computers and TV sets.

Darwinists believe they have already discovered the source of all this order, so let us look more closely at their theory. The traditional argument against Darwinism is that natural selection cannot guide the development of new organs and new systems of organs -- i.e., the development of new orders, classes and phyla -- through their initial useless stages, during which they provide no selective advantage. Natural selection may be able to darken the wings of a moth (even this is disputed), but that does not mean it can design anything complex. Consider, for example, the aquatic bladderwort, described in *Plants and Environment*, by R.F. Daubenmire (John Wiley & Sons, 1947):

The aquatic bladderworts are delicate herbs that bear bladder-like traps 5mm or less in diameter. These traps have trigger hairs attached to a valve-like door which normally keeps the trap tightly closed. The sides of the trap are compressed under tension, but when a small form of animal life touches one of the trigger hairs the valve opens, the bladder suddenly expands, and the animal is sucked into the trap. The door closes at once, and in about 20 minutes the trap is set ready for another victim.

The development of any major new feature presents similar problems, and according to Lehigh University biochemist Michael Behe, who describes several

spectacular examples in detail in *Darwin's Black Box* (Free Press, 1996), the world of microbiology is especially loaded with such examples of "irreducible complexity."

It seems that until the trigger hair, the door, and the vacuum chamber were all in place, and the ability to digest insects, and to reset the trap to be able to catch more than one insect, had been developed, none of the individual components of this carnivorous trap would have been of any use. What is the selective advantage of an incomplete vacuum chamber? To the casual observer, it might seem that none of the components of this trap would have been of any use whatever until the trap was almost perfect, but of course a good Darwinist will imagine two or three far-fetched intermediate useful stages (and maybe even find one in Nature!), and consider the problem solved. I believe you would need to find thousands of intermediate stages before this example of irreducible complexity has been reduced to steps small enough to be bridged by single random mutations -- a lot of things have to happen behind the scenes and at the microscopic level before this trap could catch and digest insects. But I don't know how to prove this. (Lest anyone imagine a lot can be accomplished by single random mutations, note that if a billion animals each typed one random character per second throughout the Earth's 4.5 billion year history, there is virtually no chance any one of them would duplicate a given 20-character string.)

I am furthermore sure that even if you could imagine a long chain of useful intermediate stages, each would present such a negligible selective advantage that nothing as clever as this insect trap could ever be produced, but I can't prove that either. Finally, that natural selection seems even remotely plausible depends on the fact that while species are awaiting further improvements, their current complex structure is "locked in," and passed on perfectly through many generations. This phenomenon is observed, but inexplicable -- I don't see any reason why all living organisms do not constantly decay into simpler components -- as, in fact, they do as soon as they die.

When you look at the individual steps in the development of life, Darwin's explanation is difficult to disprove, because some selective advantage can be imagined in almost anything. Like every other scheme designed to violate the second law, it is only when you look at the net result that it becomes obvious it won't work.

A *National Geographic* article from November 2004 proclaims that the evidence is "overwhelming" that Darwin was right about evolution. Since there is no proof that natural selection has ever done anything more spectacular than cause bacteria to develop drug-resistant strains, where is the overwhelming evidence that justifies assigning to it an ability we do not attribute to any other natural force in the universe: the ability to create order out of disorder?

Three types of evidence are cited: first, the fact that species are so well suited to their environments is offered as evidence that they have "adapted" to them. Of course, if they were not well-adapted, they would be extinct, and that would be

offered as even stronger evidence against design. Second, they point to changes due to artificial selection, where intelligent humans select features already present in the gene pool, as evidence of what can be accomplished when natural forces select among genetic accidents. But, as always, the main evidence offered is the "evolutionary tree" of similarities connecting all species, fossil and living. These similarities were of course noticed long before Darwin (many animals have four legs, one head, two eyes and a tail!); all modern science has done is to show that the similarities go much deeper than those noticed by ancient man.

Although these similarities may, to our modern minds, suggest natural causes, they do not really tell us anything about what those causes might be. In fact, the fossil record does not even support the idea that new organs and new systems of organs arose gradually: new orders, classes and phyla consistently appear suddenly. For example, Harvard paleontologist George Gaylord Simpson in "The History of Life" (in Volume I of *Evolution after Darwin*, University of Chicago Press, 1960) writes:

It is a feature of the known fossil record that most taxa appear abruptly. They are not, as a rule, led up to by a sequence of almost imperceptibly changing forerunners such as Darwin believed should be usual in evolution...This phenomenon becomes more universal and more intense as the hierarchy of categories is ascended. Gaps among known species are sporadic and often small. Gaps among known orders, classes and phyla are systematic and almost always large. These peculiarities of the record pose one of the most important theoretical problems in the whole history of life: Is the sudden appearance of higher categories a phenomenon of evolution or of the record only, due to sampling bias and other inadequacies?

Finally, I am well aware that logic and evidence are powerless against the popular perception, nurtured by prestigious journals such as *National Geographic* and *Nature*, that no serious scientists harbor any doubts about Darwinism, so I want to offer here a portion of a November 5, 1980 *New York Times* News Service report:

Biology's understanding of how evolution works, which has long postulated a gradual process of Darwinian natural selection acting on genetic mutations, is undergoing its broadest and deepest revolution in nearly 50 years. At the heart of the revolution is something that might seem a paradox. Recent discoveries have only strengthened Darwin's epochal conclusion that all forms of life evolved from a common ancestor. Genetic analysis, for example, has shown that every organism is governed by the same genetic code controlling the same biochemical processes. At the same time, however, many studies suggest that the origin of species was not the way Darwin suggested... Exactly how evolution happened is now a matter of great controversy among biologists. Although the debate has been under way for several years, it

reached a crescendo last month, as some 150 scientists specializing in evolutionary studies met for four days in Chicago's Field Museum of Natural History to thrash out a variety of new hypotheses that are challenging older ideas... At issue during the Chicago meeting was macroevolution, a term that is itself a matter of debate but which generally refers to the evolution of major differences... Darwin knew he was on shaky ground in extending natural selection to account for differences between major groups of organisms. The fossil record of his day showed no gradual transitions between such groups, but he suggested that further fossil discoveries would fill the missing links. "The pattern that we were told to find for the last 120 years does not exist," declared Niles Eldridge, a paleontologist from the American Museum of Natural History in New York. Eldridge reminded the meeting of what many fossil hunters have recognized as they trace the history of a species through successive layers of ancient sediments. Species simply appear at a given point in geologic time, persist largely unchanged for a few million years and then disappear. There are very few examples -- some say none -- of one species shading gradually into another.

SCIENCE HAS BEEN so successful in explaining natural phenomena that the modern scientist is convinced that it can explain everything. Anything that doesn't fit into this materialistic model is simply ignored. When he discovers that all of the basic constants of physics, such as the speed of light, the charge and mass of the electron, Planck's constant, etc., had to have almost exactly the values that they do have in order for any conceivable form of life to survive in our universe, he proposes the "anthropic principle" and says that there must be many other universes with the same laws, but random values for the basic constants, and one was bound to get the values right. When you ask him how a mechanical process such as natural selection could cause human consciousness to arise out of inanimate matter, he says, "human consciousness -- what's that?" And he talks about human evolution as if he were an outside observer, and never seems to wonder how he got inside one of the animals he is studying. And when you ask how the four fundamental forces of Nature could rearrange the basic particles of Nature into libraries full of encyclopedias, science texts and novels, and computers, connected to laser printers, CRTs and keyboards and the Internet, he says, well, order can increase in an open system.

The development of life may have only violated one law of science, but that was the one Sir Arthur Eddington called the "supreme" law of Nature, and it has violated that in a most spectacular way. At least that is my opinion, but perhaps I am wrong. Perhaps it only seems extremely improbable, but really isn't, that, under the right conditions, the influx of stellar energy into a planet could cause atoms to rearrange themselves into nuclear power plants and spaceships and computers. But one would think that at least this would be considered an open question, and those who argue that it really **is** extremely improbable, and thus contrary to the basic principle underlying the second law, would be given a measure of respect, and taken

seriously by their colleagues, but we aren't.

Granville Sewell is Professor of Mathematics at the University of Texas El Paso, and visiting professor at Texas A&M University. He has two new books released last summer, [Computational Methods of Linear Algebra](#), and [The Numerical Solution of Ordinary and Partial Differential Equations](#), both published by John Wiley & Sons, 2005. The latter includes an Appendix entitled, "Can ANYTHING Happen in an Open System?" which contains material referred to in this article, a long version of which can be found at the book [home page](#).

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