Intelligent Design: Humans, Cockroaches, and the Laws of Physics
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Evolution is Not the Whole Story

As the bankruptcy of creation "science" becomes increasingly recognized, a new catch phrase, intelligent design, has been adopted by those who persist in their attempts to inject creationism into the science curriculum (see, for example, Of Pandas and People, Davis 1993; Matsumura 1995 and Cole 1995 report on attempts to introduce Pandas into schools. Intelligent design is a more subtle term than creation science, one that has far broader implications than the genesis of life on a minor planet in the corner of a minor galaxy. The argument that the material universe resulted from conscious action outside itself can sound convincing, even to those who accept biological evolution as established fact. Many who agree that biblical creation is not an appropriate part of the science curriculum, because it is not science, may not object to including material that argues with greater sophistication that the universe as a whole shows evidence for design.

I can foresee proponents of intelligent design campaigning for science lessons to include statements of the sort we often read today in books and the popular press, that modern physics and cosmology have uncovered evidence for intelligence in the structure of the universe and this intelligence seems to act with us in mind (Rolston III, 1986; Wright, 1992; Begley, 1994.

In fact, science has done no such thing. Just as we must continue to educate parents and teachers on the facts of evolution, we must also inform them that science has by no means confirmed the traditional belief in a created universe with humanity at its center.

Indeed, if anything science indicates quite the opposite. Astronomical observations continue to demonstrate that the earth is no more significant than a single grain of sand on a vast beach. While a created, human-centered universe can probably never be ruled out, nothing in our current understanding of cosmology and physics requires it. Furthermore, we are beginning to understand the possible physical mechanisms for the appearance of matter from nothing, and for organization without design.

Gravity was needed to gather atoms together into stars and to compress stellar cores, raising the core temperatures to tens of millions of degrees. These high temperatures made nuclear reactions possible, and over billions of years the elements of the chemical periodic table were synthesized as the by-product.

When the nuclear fuel in the more massive, faster- burning stars was spent, the laws of physics called for them to explode as supernovae, sending into space the elements manufactured in their cores. In space, gravity could gather these elements into planets circling the smaller, longer-lived stars. Finally, after about ten billion years, the carbon, oxygen, nitrogen and other elements on a small planet attached to a small, stable star could begin the process of evolution toward the complex structures we call life.

In recent years, creationist theologians, and even a few physicists, have heavily promoted what they claim is a remarkable fine-tuning of the basic laws and constants of physics, without which life as we know it would

never have developed (Barrow, 1986; Rolston III). If the universe had appeared with slight variations in the strengths of the fundamental forces or the masses of elementary particles, that universe would be pure hydrogen at one extreme, or pure helium at the other.

Neither would have allowed for the eventual production of heavy elements, such as carbon, necessary for life. Similarly, if gravity had not been many orders of magnitude weaker than electromagnetism, stars would not have lived long enough to produce the elements of life. Long before they could fabricate heavy chemical elements, stars would have collapsed. Only the fact that the gravitational force was forty orders of magnitude weaker prevented this from happening. In a calculation similar to Hoyle's, mathematician
Roger Penrose has estimated that the probability of a universe with our particular set of physical properties is one part in 10^10^123 (Penrose 1989: 343). However, neither Penrose nor anyone else can say how many of the other possible universes formed with different properties could still have lead to _some_ form of life.

If it is half, then the probability for life is fifty percent. Ignoring this absent link in their chain of logic, promoters of intelligent design put forward the so-called _anthropic coincidences_ as evidence for a universe that was created with humans in mind. I have heard Christian philosopher William Lane Craig make this claim in a debate on the existence of God. In the same debate, Craig contended that the great age of the universe, which
dwarfs human history, is in fact a sign of God's plan for humanity because billions of years were needed to allow life to evolve. (Craig evidently accepts evolution).

You would have thought God could be a lot more efficient. And Craig did not rationalize why humanity rather than cockroaches was the goal God had in mind. So as you see, we have a lot more explaining to do after we explain how life developed on earth by natural processes. Even if life evolved naturally on earth with no outside interference, the existence of stars and planets, quarks and electrons, and the very laws of physics themselves can be presented as evidence for intelligent design to the universe. Furthermore, given the egocentrism that seems to characterize the human race, convincing people that the universe was designed with them in mind is as easy as convincing a child that candy is good for him.

Perhaps the universe was created for the sole purpose of producing you and me. I have no objection to discussing the possibility, as long as the discussion is critical, rational, and objective. The most common argument that is still given by believers when they are asked to present _scientific_ evidence for a creator is: "How can all of this (gesturing to the world around us) have happened by chance?" As we have seen, the most brilliant exposition of the case for evolution will not answer this question, because it still presumes the pre-existence of laws of physics and values of physical constants that had to be delicately balanced for human (and cockroach) life to evolve.

The Argument from Probability

Before addressing the question of how the laws of physics can have come about in the absence of intelligent design, let me provide a response to the arguments from probability outlined above.

If we properly compute, according to statistical theory, the probability for the universe existing with the properties it has, the result is unity! The universe exists with one hundred percent probability (unless you are an idealist who believes everything exists only in your own mind). On the other hand, the probability for one of a random set of universes being our particular universe is a different question. And the probability that one of a random set of universes is a universe that supports _some _form of life is a third question. I submit it is this last question that is the important one and that we have no reason to be sure that this probability is small.

I have made some estimates of the probability that a chance distribution of physical constants can produce a universe with properties sufficient that some form of life would have likely had sufficient time to evolve. In this study, I randomly varied the constants of physics (I assume the same laws of physics as exist in our universe, since I know no other) over a range of ten orders of magnitude around their existing values. For each resulting "toy" universe, I computed various quantities such as the size of atoms and the lifetimes of stars. I found that almost all combinations of physical constants lead to universes, albeit strange ones, that would live long enough for some type of complexity to form (Stenger 1995: chapter 8). This is illustrated in figure 1.

Every shuffle of a deck of cards leads to a 52-card sequence that has low _a priori_ probability, but has unit probability once the cards are all on the table. Similarly, the "fine-tuning" of the constants of physics, said to be so unlikely, could very well have been random; we just happen to be in the universe that turned up in that particular deal of the cards.

Note that my thesis does not require more than one universe to exist, although some cosmological theories propose this. Even if ours is the only universe, and that universe happened by chance, we have no basis to conclude that a universe without some form of life was so unlikely as to have required a miracle.

Simplicity and Physical Law

So the argument from probability fails. Many sets of physical constants could have produced a universe with life, albeit life very unlike our own. But what about the laws of physics themselves? Can we take their mere _existence_ as evidence for intelligent design?

Let me begin by addressing two commonsense notions: (1) you cannot get something from nothing, and (2) the order of the universe requires the pre-existence of an active intelligence to do the ordering. I will leave it to the theologians to explain how the postulate of a creator God solves the problem of _creation ex nihilo _, since God is something that, itself, must have come, uncreated, from nothing. Instead I will address the physics issues implied by the creation of the universe from nothing. In physics terms, _creation ex nihilo_ appears to violate both the first and second laws of thermodynamics.

The first law of thermodynamics is equivalent to the principle of conservation of energy: the total energy of a closed system is constant; any energy change must be compensated by a corresponding inflow or outflow from the system.

Einstein showed that mass and energy are equivalent, by E = mc^2. So, if the universe started from "nothing, " energy conservation would seem

to have been violated by the creation of matter. Some energy from outside is apparently required.

However, our best estimate today is that the total energy of the universe is zero (within a small _zero point energy _ that results from quantum fluctuations), with the positive energy of matter balanced by the negative potential energy of gravity. Since the total energy is zero, no energy was needed to produce the universe and the first law was not violated.

The second law of thermodynamics requires that the _entropy_, or disorder, of the universe must increase or at least stay constant with time. This would seem to imply that the universe started out in a greater state of order than it has today, and so must have been designed.

However, this argument holds only for a universe of constant volume. The maximum entropy of any object is that of a black hole of the same volume. In an expanding universe, the maximum allowable entropy of the universe is continually increasing, allowing more and more room for order to form as time goes by. If we extrapolate the big bang back to the earliest definable time, the so- called _Planck time _(10^-43 second), we find that universe started out in a condition of maximum entropy-- total chaos. The universe had no order at the earliest definable instant. If there was a creator, it had nothing to create.

Note also that one cannot ask, much less answer, "What happened before the big bang?" Since no time earlier than the Planck time can be logically defined, the whole notion of time before the big bang is meaningless.

Furthermore, within the framework of Einstein's relativity, time is the fourth dimension of spacetime. Defining this fourth dimension as ict, where t is what you read on a clock, i = sqrt(-1), and c is the speed of light, the coordinates of time and space are interchangeable. In short, time is inextricably intertwined with space and came into being "when" or "where" (language is inadequate to mathematics here) spacetime came into being.

Spontaneous Order

So, where did the order of the universe come from, if it did not exist at the "beginning"? Where did the laws of physics come from, if not from some great lawgiver? We are now beginning to grasp how the laws of physics could have come about _naturally_, as the universe spontaneously exploded in the big bang.

To understand this, we first have to recognize the prejudice that is built into the whole concept of physical law. When Newton developed mechanics and gravity, the Judeo-Christian notion of God-given law was already deeply engraved in his thinking, by his culture. Even today, science is interpreted by public, media, and scientists alike as the process of learning the "mind of God."[1]

However, the laws of physics, at least in their formal expressions, are no less human inventions than the laws by which we govern ourselves. They represent our imperfect attempts at economical and useful descriptions of the observations we make with our senses and instruments.

This is not to say we subjectively determine how the universe behaves, or that it has no orderly behavior. Few scientists deny that an objective,

ordered reality exists that is independent of human life and experience. We simply have to recognize that the concept of "natural law" carries with it certain metaphysical baggage that is tied to our traditional, pre-scientific modes of thought. We are going a step beyond logic to conclude that the existence in the universe of order, which we conventionally label as the laws of nature, implies a cosmic lawgiver.

We are gradually learning that several of the laws of physics, those that seem the most universal and profound, are in fact little more than statements about the simplicity of nature that can almost go unsaid. The "laws" of energy, momentum, and angular momentum conservation have been shown to be statements about the homogeneity of space and time. The first law of thermodynamics, conservation of energy, results from there being no unique moment in time.[2]

Conservation of momentum follows from the Copernican principle that there is no preferred position in space. Other conservation laws, such as charge and nucleon number, also arise from analogous assumptions of simplicity.

For the mathematically inclined, the conserved quantities are _generators_ of the symmetry transformations involved. A homogeneous universe, one with a high level of symmetry, is the simplest of all possible universes, just the kind we would expect to happen by accident. In such a universe, many conservation laws will automatically exist.

In general, the conservation laws need no explanation beyond the mathematical symbols used to represent the corresponding symmetry. On the other hand, an observed violation of a conservation law would demand an explanation, for then we would have evidence for a deviation from simplicity and homogeneity. To explain this deviation, we have to go beyond the assumptions that require the fewest parameters, that is, are the most economical.

By an equally simple but somewhat different argument, the second law of thermodynamics is found not to be some underlying principle of the universe, but rather an arbitrary convention we humans make in defining the direction of time. Nothing in known fundamental physics forbids the violation of the second law. No mechanical principle prevents the air emptying from a room when you open the door, killing everyone inside. Physics does not forbid a human from growing younger or the dead rising! All that has to happen for these "miraculous" events is that the molecules involved are accidentally moving in the right direction at the right instant. Of course these miracles are not observed to happen except in fantasies, but only because they are so highly unlikely.

We introduce the second "law" to codify what all of human experience testifies, that air does not empty from a room, people do not grow younger, and the dead do not rise. But these events are not impossible, just highly improbable. Influenced, like Newton, by our culture, we falsely state that these unlikely events cannot happen because the second law "forbids" them from doing so.

The second law of thermodynamics, along with the arrow of time and the notions of causality and determinism, arise as statistical statements about the likelihood of events that emerge as principles we invent to describe the world of everyday experiences.

Other, more complex and less universal laws of physics appear to arise from _spontaneously broken symmetries_. When a quantity such as momentum is observed not to be conserved, we introduce the notion of a "force" to break the corresponding spatial symmetry. By this means, the force laws and other principles that give structure to the universe arise as spontaneously broken symmetries--accidental, uncaused events that occurred in the first fraction of a second of the big bang as the expanding universe cooled. The process can be likened to the formation of structure in a snowflake from water vapor, or the magnetizing of a bar of iron cooled below the Curie temperature.

The Appearance of Structure

While the details of the symmetry-breaking mechanism referred to here are not fully developed, and further work may negate this picture, we have at least one highly successful example of how the process of spontaneous structure formation from underlying symmetry and chaos can have come about. The current theory of elementary particles, the so-called _Standard Model_ of quarks and leptons (the electron and neutrino are examples of leptons), agrees with all existing observations about the material world. In two decades since its inception, no violation of the Standard Model has been observed.

Within the framework of this model, electromagnetic and weak nuclear forces are viewed as low-energy manifestations of a single, unified _electroweak_ force that applies at higher energies and smaller distances. At the level of most observations, these forces are vastly different. The electromagnetic force acts over macroscopic distances, while the electroweak force is confined to the atomic nucleus. The two forces differ enormously in strength. Yet the Standard Model treats them in a unified fashion at high energies, and explains their differing structure by means of spontaneous symmetry breaking that occurs at lower energies.

Further progress in understanding these fundamental mechanisms has been slowed by the canceling of the Superconducting Supercollider that would have probed beyond the Standard Model. A less ambitious (although still gigantic) project is going ahead in Europe, but it will be a new millennium before physicists have the data they will need to determine whether spontaneous symmetry breaking is indeed the process by which the laws of physics evolved in the first fraction of a second of the big bang. Currently, all we can say is that we have one firm example, and many theoretical suggestions, that will not be tested experimentally for another decade. Even if they all fail these tests, it seems highly unlikely that the process will yield evidence for the creator of Judeo-Christian-Islamic theology.

Implications for Education

In critically examining evidence for or against intelligent design to the universe, it must be understood that we are following the traditional practice of science, seeking a scientific explanation for observations about the universe that have been previously attributed to the action of supernatural deity. Believers will call us nasty names, like "atheist" and "secular humanist," and accuse us of undermining faith and morality. Certainly we cannot be dogmatic in our approach, or appear to be preaching a religion of "scientism." If we do, then we have no more right to a piece of the science curriculum than the religionists.

As in any scientific investigation, we must emphasize our commitment to the scientific process and agree to accept whatever the conclusion of that process may be. If that conclusion is evidence for supernatural intelligent design, then so be it. But if we cannot find such evidence, then we should not feel compelled to soothe the sensitivities of believers by leaving unchallenged the assertion that their sectarian prejudices have scientific merit. We must speak out forcefully whenever anyone claims scientific authority for beliefs that fail the objective tests of scientific method.

I realize that the ideas I have covered in this essay will be very difficult to explain in the classroom, even at the university level where few students study physics at anything more than a minimal, descriptive level--if they study it at all. Nevertheless, we should not leave the field open to those who demonstrate no commitment to scientific truth.

If teachers cannot understand or explain the developments in modern physics I have outlined above, they can at least emphasize the need to pursue these issues in an open, objective, and rational fashion. They should point out the logical flaws in the anthropic probability argument, that we must count all the possible ways that life may have developed. And they can question the claim that _creation ex nihilo_ violates the laws of physics, that science requires a miracle to produce the universe.

At the least, teachers should be made aware of the fact that modern physics and cosmology provide no compulsion to introduce the uneconomical hypothesis of a biblical creator. They must resist those who would attempt to force their personal beliefs into the classroom through the back door of "intelligent design."

The process in which we are engaged is the search for rational evidence for or against intelligent design. It does not suffice to say that intelligent design is possible, and proponents of intelligent design have no right to re-cast the question as one in which the non-existence of intelligent design must be proven. Within the framework of Occam's razor, intelligent design is an added hypothesis and the proponent's burden is to demonstrate why it is necessary to make this hypothesis.

I have argued that no evidence or rational argument for intelligent design can be found in either the data or the theories of modern physics and cosmology. If the hypothesis of intelligent design is to be discussed in science classrooms, then good science methodology demands that we make clear that this is an uneconomical hypothesis that is not required by existing scientific knowledge.

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