Is There Scientific Evidence for the Existence of God? How the Recent Discoveries Support a Designed Universe

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Introduction -- What is implied by the concept of "an intelligently designed universe"?

What does it mean on a grand scale to assert that the universe is the product of an intelligent designer? In a scientific age that exalts rationalism and chance, what empirical evidence could possibly support such a claim? As humans contemplating the immense complexity of the cosmos, might certain features of the universe suggest that our "home" has in fact been carefully crafted for our benefit? Can our own human experiences of creativity and design illuminate the concept of a cosmic designer? These questions underlie the discussion of intelligent design theory, a resurgent area of inquiry by both Christian and secular scientists in search of a reasonable explanation for the marvelous complexity of the universe.

In his classic, *Natural Theology* (1802),{1} eighteenth-century English philosopher and theologian William Paley marshaled evidence for a designed universe from both the physical and biological sciences. However, his argument for design was called into question by Darwin's theory of evolution. But new discoveries in the latter half of the twentieth century in the fields of astronomy, cosmology, and abiogenesis (the origin of life) have provided extremely compelling evidence for a designed universe. These findings have been publicized in the popular print media (*Time*, December 1992 and *Newsweek*, July 1998), featured in television specials on PBS and BBC, and disseminated through a wide variety of popular and scholarly books, including entries from prestigious academic publishing houses such as Oxford and Cambridge University Presses.

My personal experience as a lecturer supports the growing openness to intelligent design theory in the academic world. Having given over 135 talks on this subject to more than 65,000 students and professors at over 65 major university campuses from 1986 to 2002, I have observed a dramatic change in audience receptivity to the idea that an intelligent designer of the universe may exist. I have noted a widespread acceptance (albeit begrudging in some quarters) that this growing body of scientific evidence demands an intellectually honest reckoning, as no exclusively naturalistic explanation seems capable of rising to the occasion.

Before we examine the evidence from cosmology, physics, and chemistry that suggests the universe has been designed as an ideal habitat for life in general and for humans in particular, let me first clarify what is meant by the term "design."

How Can We Identify Designed Objects in the Natural World?

Richard Dawkins, a British zoologist and one of the world's foremost apologists for classical Darwinism, addressed the question of design in his 1996 essay collection, *Climbing Mount Improbable*,{2} by contrasting particular, designed artifacts with similar accidents in nature. Dawkins illustrates the concept of design with the example of Mount Rushmore, upon which are carved the clearly recognizable images of Presidents Washington, Jefferson, Lincoln and Theodore Roosevelt (Figure 1). By contrast, a naturally occurring rock in Hawaii casts a shadow that resembles President John F. Kennedy (Figure 2), illustrating an accidental occurrence in nature. It is self-evident that a sculptor (in this case, Gutzon Borglum) carved Mount Rushmore. The sheer number of details in which the Mount Rushmore faces resemble the faces of the four presidents testifies to the presence of an intelligent cause, a human sculptor. No one could seriously attribute these magnificent faces to the creative forces of wind, rain, sleet, and hail.

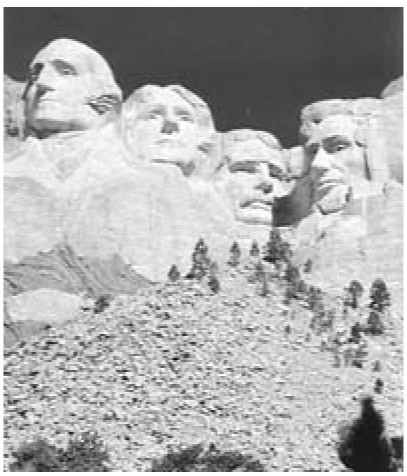


Figure 1. An intelligent design: Mount Rushmore with presidents Washington, Jefferson, Roosevelt, and Lincoln.

Figure 2. An accident of nature: President John F. Kennedy's profile formed by shadow cast by a large rock in Hawaii.

Dawkins defines *designoids* as artifacts of the natural world that appear to be designed but "have in fact been shaped by a magnificently non-random process which creates an almost perfect illusion of design."{2} A *designoid* is an artifact in nature that looks like Mount Rushmore but can in fact be explained by natural processes (with, say, natural selection being the non-random process in the case of living systems).

The first step in evaluating the possibility of intelligent design is to examine closely the characteristics (or artifacts) of the natural world in order to assess whether all external "appearances" of design are merely "designoids," or whether they are, in fact, true examples of design by an intelligent Creator. Let us begin by considering the essential elements of intelligent design by human beings.

How Does An Engineer Design Consumer Products?

Design engineers using their understanding of natural laws, as described by mathematics, and their capacity to prescribe the conditions under which these natural laws function locally to produce a purposeful outcome. Let me illustrate. Suppose I wanted to throw a water balloon from the leaning Tower of Pisa in Italy to hit a friend walking on the plaza below. Solving the differential equation that Newton discovered for motion in a gravitational field, I would obtain a solution in the form of a simple, algebraic equation that describes the descent of the water balloon to its target below.

$$H(t) = h_0 - (Gm / r^2)\, t^2 / 2 - v_0 t \qquad \textbf{(1)}$$

Here "H(t)" represents the height of the balloon as a function of time ("t"); "G" is a universal constant signifying the strength of the gravitational force of attraction; "m" and "r" are the mass of the Earth and the radius of the Earth, respectively; and "h_0" and "v_0" are the height of the tower from which I shall throw the balloon, and the vertical velocity with which I shall throw the balloon, respectively. By entering the numerical values for "G," "m," and "r," I obtain $Gm/r^2 = 32.2$ ft/s^2 , usually designated "g." Now Equation 1 can be simplified to:

$$H(t) = h_o - g\, t^2 / 2 - v_o\, t = h_o - 32.2\, t^2 / 2 - v_o\, t \qquad \textbf{(2)}$$

I can now solve Equation 2 for the time "t" it will take for the water balloon to reach the ground [H(t) = 0] if I specify the height of the tower [h_o] and the initial velocity [v_o] with which the water balloon is thrown. This equation may be used to guarantee that my balloon arrives at the plaza at just the right time to hit my strolling friend. Simply dropping the balloon will also accomplish my goal. I specify $v_0 = 0$ and $H(t) = 0$ and solve for the correct time to drop the balloon.

Human Design Consists in Setting the Boundary Conditions

These three essential factors to predict the motion of my water balloon are the same ones generally necessary to achieve design outcomes in engineering. They are:

- the mathematical form that nature takes (see Equations 1 and 2);
- the values of the universal constants (G in Equation 1) and local constants (the radius of Earth, r, and the mass of the Earth, m, in Equation 1); and
- the boundary conditions (the height [h_0] and initial velocity [v_0] in this example.

Note that the engineer has no control over the laws of nature and the mathematical forms they assume. Neither does the engineer have any control over the values of the universal constants, such as the gravity force constant. The engineer can only set the boundary conditions; for example, when drawing up blueprints to specify exactly how a device will look and operate when it has been manufactured.

If we revisit the design process, this time using the more realistic--though complex--example of automobile design, the engineer must carefully prescribe the boundary conditions such that the chemical energy released by the internal combustion of gasoline is converted into mechanical energy in the form of torque to the car wheels. Furthermore, the dimensions for each engine part are of critical importance. The absolute size and shape of each part is determined by the car's desired weight, speed, passenger and luggage capacity, and other performance specifications. These factors determine the size of the engine cylinders and pistons and the rate of gasoline injected into the engine cylinders, the scale of the brake and suspension systems, the size and type of tires, and so forth. And whatever their absolute characteristics, the parts chosen must also be scaled in relationship to one another so that they can work together harmoniously.

Notice that many of the specifications are related to each other and therefore cannot be independently specified or assigned. The greater this interdependence of specified boundary conditions, the more complex and demanding is the design process. Small errors in the specification of any such requirement will produce either a car with very poor performance or, worse, a car that does not function at all.

In summary, we can see that human design consists in specification of conditions under which the laws of nature operate to produce a purposeful outcome. In the next section, we will see that cosmic design involves specification of not only the conditions under which the laws of nature operate, but the laws themselves and the universe constants that scale the "building blocks" (e.g., rest masses of elemental particles), "energy blocks" (e.g., quanta of energy), and the fundamental forces in nature to provide the purposeful outcome of a habitable universe for life, and life itself!

Needs Statement for a Habitable Place in a Suitable Universe

We teach mechanical engineering students to begin the design process by specifying as clearly as possible the "needs statement" for their project. Then, the assignment for the semester is to develop a design solution that accomplishes the "need(s)" specified for the project. In similar fashion, the minimal needs to be satisfied for a universe to be capable of supporting life of any imaginable type, not just life as we know it, must be identified. Like our automobile illustration, many of the specifications will necessarily be interrelated to make a functional universe. From this essential "needs statement" we can then see how these needs (or design requirements) are met in our universe. We are essentially doing reverse engineering, constructing the blueprint backwards from the product (like an illicit manufacturing company copying a competitor's product). Only then will we be ready to entertain Dawkins' question, "Are there many ways in which these requirements could be satisfied within nature?"{2} Or are the conditions so unique and interrelated that their collective satisfaction by accident would be a "miracle" in its own right? Let us then begin by drafting a "needs statement" for a habitable universe. Then we shall see how these requirements are satisfied in our universe.

Needs Statement for a Suitable Universe

An abbreviated list of requirements for a universe suitable to support life of any imaginable type must include the following items:

- *Order* to provide the stable environment that is conducive to the development of life, but with *just enough chaotic behavior* to provide a driving force for change.
- *Sufficient chemical stability and elemental diversity* to build the complex molecules necessary for essential life functions: processing energy, storing information, and replicating. A universe of just hydrogen and helium will not "work."
- *Predictability in chemical reactions*, allowing compounds to form from the various elements.
- *A "universal connector,"* an element that is essential for the molecules of life. It must have the chemical property that permits it to react readily with almost all other elements, forming bonds that are stable, but not too stable, so disassembly is also possible. Carbon is the only element in our periodic chart that satisfies this requirement.
- *A "universal solvent"* in which the chemistry of life can unfold. Since chemical reactions are too slow in the solid state, and complex life would not likely be sustained as a gas, there is a need for a liquid element or compound that readily dissolves both the reactants and the reaction products essential to living systems: namely, a liquid with the properties of water.
- *A stable source of energy to sustain living systems* in which there must be photons from the sun with sufficient energy to drive organic, chemical reactions, but not so energetic as to destroy organic molecules (as in the case of highly energetic ultraviolet radiation).
- *A means of transporting the energy* from the source (like our sun) to the place where chemical reactions occur in the solvent (like water on Earth) must be available. In the process, there must be minimal losses in transmission if the energy is to be utilized efficiently.

Unless **ALL** of these conditions and many more not included in this list are met, we would have a universe that would preclude the possibility of conscious, complex life forms. However, it is possible to meet all of these conditions for the universe and still not necessarily find a suitable habitat in the universe for complex, conscious life. Therefore, we might say that the above requirements for our universe are necessary, but not by themselves sufficient, conditions for a habitat suitable for complex human life. Next we try to identify the additional conditions within such a suitable universe that would provide a place of habitation for conscious, complex life.

Needs Statement for a Habitat Place in the Suitable Universe for Complex, Conscious Life

An abbreviated, but illustrative, list of additional requirements must be specified for a place of habitation in this universe. First, we need a star that is located in a relatively "quiet" region of the universe (e.g., not too many neighbors that are producing high intensity, sterilizing radiation). This star needs to have its highest intensity of radiation in the range that is suitable to drive the chemical reactions essential to life without destroying the products of these reactions. Furthermore, this star needs to have a very special satellite within its solar system. A partial list of the requirements this satellite must meet include:

- a planet or moon that is terrestrial--or, solid rather than gaseous;
- a temperature range suitable to maintain the universal solvent as a liquid rather than a solid or gas;
- just the right concentration of heavy (radioactive) elements to heat the core of the planet and provide the necessary energy to drive plate tectonics, to build up land mass in what would otherwise be a smooth, round planet completely covered with solvent;
- just the right amount of solvent (carefully coupled to the plate tectonics activity) to provide a planet with similar proportions of its surfaces as oceans and land mass;
- just the right protection from the destructive forces in nature such as radiation and asteroids over a reasonable amount of time; and
- just the right stabilized axis tilt and angular velocity to give moderate, regular, and predictable seasons and moderate temperature fluctuations from day to night.

While one is temped to think that these requirements are easily met, given the large number of stars, it should be noted that there are few places in the universe sufficiently free of sterilizing radiation to provide a suitable solar system. The number of candidate "neighborhoods" is further reduced by the requirements of a sun with the right amount of mass to give the right electromagnetic radiation spectrum. Furthermore, the occurrence of a suitable satellite in conjunction with such a star is even more problematic. Only the earth in our solar system of sixty-two satellites meets the above requirements for a "home" (earth) in safe "neighborhood" like our sun and solar system, which are well placed in a quiet place in a suitable universe as described above.

In the next sections, we will see how these universal and local "needs" (or design requirements) are met by: the specific mathematical form encoded in nature, the exact values of the universal constants in our universe, and the remarkable "coincidence" that initial (or boundary) conditions are exactly what they must be. We will also see that the "evolutional" or developmental path that our universe navigated is consistently remarkable, making the origin of our "Garden of Eden" all the more wondrous and enigmatic.

Blueprint for a Habitable Universe - Mathematics and the Deep Structure of the Universe

Mathematics--in contrast to mere calculation--is an abstract intellectual activity that began in Greece in the sixth century BC. Pythagoras was a key figure, as were his successors, Euclid and Archimedes. Their studies focused especially on geometric objects such as straight lines, circles, ellipses, and conic sections (i.e., the curves made by cutting a cone with a plane).

In the third century BC, Appolonius of Perga wrote eight monumental volumes devoted to these curves, describing their properties as "miraculous." Yet the geometric and mathematical formulations to which they devoted themselves were actually descriptions encoded into the very fabric of nature. Imagine the delight of Johannes Kepler (1571-1630) some eighteen centuries later, when he discovered that the orbits of planets around the sun conformed to these same beautiful but abstract mathematical forms. Kepler declared: "The chief aim of all investigations of the external world should be to discover the rational order and harmony which has been imposed on it by God and which He revealed to us in the language of mathematics."{3}

Galileo Galilei (1564-1642) asserted that "the laws of nature are written by the hand of God in the language of mathematics."{4} In his *Mathematics: The Loss of Certainty,*{5} historian Morris Kline demonstrates that the religious mathematicians of the sixteenth and seventeenth centuries--including Newton, Galileo, Kepler, and Copernicus--viewed the universe as orderly and capable of mathematical description precisely because a rational God had fashioned it thus. These scientist-mathematicians believed that, since God had designed the universe, then "all phenomena of nature would follow one master plan. One mind designing a universe would almost surely have employed one set of basic principles to govern all related phenomena."{5}

Only in the 20th century have we come to fully understand that the incredibly diverse phenomena that we observe in nature are the outworking of a very small number of physical laws, each of which may be described by a simple mathematical relationship. Indeed, so simple in mathematical form and small in number are these physical laws that they can all be written on one side of one sheet of paper, as seen in Table 1.

Physicists and Nobel laureate Eugene Wigner in his widely quoted paper, *The Unreasonable Effectiveness of Mathematics in the Physical Sciences* notes that scientists often take for granted the remarkable--even miraculous--effectiveness of mathematics in describing the real world. Wigner muses:

The enormous usefulness of mathematics is something bordering on the mysterious . . . . There is no rational explanation for it . . . . The miracle of the appropriateness of the language of mathematics for the formulation of the laws of physics is a wonderful gift which we neither understand nor deserve.{6}
Albert Einstein was struck by the wondrous orderliness of the world.
You find it strange that I consider the comprehensibility of the world (to the extent that we are authorized to speak of such a comprehensibility) as a miracle or as an eternal mystery. Well, *a priori* one should expect a chaotic world, which cannot be grasped by the mind in any way . . . . [T]he kind of order created by Newton's theory of gravitation, for example, is wholly different. Even if man proposes the axioms of the theory, the success of such a project presupposes a high degree of ordering of the objective world, and this could not be expected *a priori.* That is the "miracle" which is being constantly reinforced as our knowledge expands.{7}

Table 1. The Fundamental Laws of Nature.

- Mechanics (Hamilton's Equations)
  $p = -\frac{\partial H}{\partial q} \qquad q = -\frac{\partial H}{\partial p}$
- Electrodynamics (Maxwell's Equations)
  $F^{\mu\upsilon} = \partial^{\mu} A^{\upsilon} - \partial^{\upsilon} A^{\mu}$

  $\partial_{\mu} F^{\mu\upsilon} = j^{\upsilon}$
- Statistical Mechanics (Boltzmann's Equations)
  $S = -k \int f \log f \, dv$

  $\frac{dS}{dt} \geq 0$
- Quantum Mechanics (Schrödinger's Equations)
  $I \, h |\psi\rangle = H |\psi\rangle$

  $\Delta X \Delta P \geq \frac{h}{2}$
- General Relativity (Einstein's Equation)
  $G_{\mu\upsilon} = -8\pi G T_{\mu\upsilon}$

Yet even the splendid orderliness of the cosmos, expressible in the mathematical forms seen in Table 1, is only a small first step in creating a universe with a suitable place for habitation by complex, conscious life. The particulars of the mathematical forms themselves are also critical. Consider the problem of stability at the atomic and cosmic levels. Both Hamilton's equations for non-relativistic, Newtonian mechanics and Einstein's theory of general relativity (see Table 1) are unstable for a sun with planets unless the gravitational potential energy is proportional to r^{-1}, a requirement that is only met for a universe with three spatial dimensions. For Schrödinger's equations for quantum mechanics to give stable, bound energy levels for atomic hydrogen (and by implication, for all atoms), the universe must have no more than three spatial dimensions. Maxwell's equations for electromagnetic energy transmission also require that the universe be no more than three-dimensional.

Richard Courant illustrates this felicitous meeting of natural laws with the example of sound and light: "[O]ur actual physical world, in which acoustic or electromagnetic signals are the basis of communication, seems to be singled out among the mathematically conceivable models by intrinsic simplicity and harmony."{8}

To summarize, for life to exist, we need an orderly (and by implication, intelligible) universe. Order at many different levels is required. For instance, to have planets that circle their stars, we need Newtonian mechanics operating in a three-dimensional universe. For there to be multiple stable elements of the periodic table to provide a sufficient variety of atomic "building blocks" for life, we need atomic structure to be constrained by the laws of quantum mechanics. We further need the orderliness in chemical reactions that is the consequence of Boltzmann's equation for the second law of thermodynamics. And for an energy source like the sun to transfer its life-giving energy to a habitat like Earth, we require the laws of electromagnetic radiation that Maxwell described.

Our universe is indeed orderly, and in precisely the way necessary for it to serve as a suitable habitat for life. The wonderful internal ordering of the cosmos is matched only by its extraordinary economy. Each one of the fundamental laws of nature is essential to life itself. A universe lacking any of the laws shown in Table 1 would almost certainly be a universe without life. Many modern scientists, like the mathematicians centuries before them, have been awestruck by the evidence for intelligent design implicit in nature's mathematical harmony and the internal consistency of the laws of nature. Australian astrophysicist Paul Davies declares:

All the evidence so far indicates that many complex structures depend most delicately on the existing form of these laws. It is tempting to believe, therefore, that a complex universe will emerge only if the laws of physics are very close to what they are....The laws, which enable the universe to come into being spontaneously, seem themselves to be the product of exceedingly ingenious design. If physics is the product of design, the universe must have a purpose, and the evidence of modern physics suggests strongly to me that the purpose includes us.{9}

British astronomer Sir Fred Hoyle likewise comments,

I do not believe that any scientist who examines the evidence would fail to draw the inference that the laws of nuclear physics have been deliberately designed with regard to the consequences they produce inside stars. If this is so, then my apparently random quirks have become part of a deep-laid scheme. If not then we are back again at a monstrous sequence of accidents.{10}

Nobel laureates Eugene Wigner and Albert Einstein have respectfully evoked "mystery" or "eternal mystery" in their meditations upon the brilliant mathematical encoding of nature's deep structures. But as Kepler, Newton, Galileo, Copernicus, Davies, and Hoyle and many others have noted, the mysterious coherency of the mathematical forms underlying the cosmos is solved if we recognize these forms to be the creative intentionality of an intelligent creator who has purposefully designed our cosmos as an ideal habitat for us.

Blueprint for a Habitable Universe: Universal Constants - Cosmic Coincidences?

Next, let us turn to the deepest level of cosmic harmony and coherence - that of the elemental forces and universal constants which govern all of nature. Much of the essential design of our universe is embodied in the scaling of the various forces, such as gravity and electromagnetism, and the sizing of the rest mass of the various elemental particles such as electrons, protons, and neutrons.

There are certain universal constants that are indispensable for our mathematical description of the universe (see Table 2). These include Planck's constant, h; the speed of light, c; the gravity-force constant, G; the rest masses of the proton, electron, and neutron;

the unit charge for the electron or proton; the weak force, strong nuclear force, electromagnetic coupling constants; and Boltzmann's constant, k.

Table 2. Universal Constants.

- Speed of light — $c = 3.0 \times 10^{8}$ m/s
- Planck's constant — $h = 6.63 \times 10^{-34}$ J-s
- Boltzmann's constant — $k = 1.38 \times 10^{-23}$ J / ^{o}K
- Unit charge — $q = 1.6 \times 10^{-19}$ Coulombs
- Rest mass proton — $mp = 1.67 \times 10^{-27}$ kg
- Rest mass of neutron — $mn = 1.69 \times 10^{-27}$ kg
- Rest mass of electron — $me = 9.11 \times 10^{-31}$ kg
- gravity force constant — $G = 6.67 \times 10^{-11}$ N-m^{2}/ kg^{2}

When cosmological models were first developed in the mid-twentieth century, cosmologists naively assumed that the selection of a given set of constants was not critical to the formation of a suitable habitat for life. Through subsequent parametric studies that varied those constants, scientists now know that relatively small changes in any of the constants produce a dramatically different universe and one that is not hospitable to life of any imaginable type.

The "just so" nature of the universe has fascinated both scientists and laypersons, giving rise to a flood of titles such as *The Anthropic Cosmological Principle*,{11} *Universes*,{12} *The Accidental Universe*,{13} *Superforce*,{14} *The Cosmic Blueprint*,{15} *Cosmic Coincidences*,{16} *The Anthropic Principle*,{17} *Universal Constants in Physics*,{18} *The Creation Hypothesis*,{19} and *Mere Creation: Science, Faith and Intelligent Design.*{20} Let us examine several examples from a longer list of approximately one hundred requirements that constrain the selection of the universal constants to a remarkable degree.

Twentieth-century physicists have identified four fundamental forces in nature. These may each be expressed as dimensionless numbers to allow a comparison of their relative strengths. These values vary by a factor of 10^{41} (10 with forty additional zeros after it), or by 41 orders of magnitude. Yet modest changes in the relative strengths of any of these forces and their associated constants would produce dramatic changes in the universe, rendering it unsuitable for life of any imaginable type. Several examples to illustrate this fine-tuning of our universe are presented next.

Balancing Gravity and Electromagnetism Forces - Fine Tuning Our Star and Its Radiation

The electromagnetic force is 10^{38} times stronger than the gravity force. Gravity draws hydrogen into stars, creating a high temperature plasma. The protons in the plasma must overcome their electromagnetic repulsion to fuse. Thus the relative strength of the gravity force to the electromagnetic force determines the rate at which stars "burn" by fusion. If this ratio of strengths were altered to10^{32} instead of 10^{38} (i.e., if gravity were much stronger), stars would be a billion times less massive and would burn a million times faster.{21}

Electromagnetic radiation and the light spectrum also depend on the relative strengths of the gravity and electromagnetic forces and their associated constants. Furthermore, the frequency distribution of electromagnetic radiation produced by the sun must be precisely tuned to the energies of the various chemical bonds on Earth. Excessively energetic photons of radiation (i.e., the ultraviolet radiation emitted from a blue giant star) destroy chemical bonds and destabilize organic molecules. Insufficiently energetic photons (e.g., infrared and longer wavelength radiation from a red dwarf star) would result in chemical reactions that are either too sluggish or would not occur at all. All life on Earth depends upon fine-tuned solar radiation, which requires, in turn, a very precise balancing of the electromagnetic and gravitational forces.

As previously noted, the chemical bonding energy relies upon quantum mechanical calculations that include the electromagnetic force, the mass of the electron, the speed of light (c), and Planck's constant (h). Matching the radiation from the sun to the chemical bonding energy requires that the magnitude of six constants be selected to satisfy the following inequality, with the caveat that the two sides of the inequality are of the same order of magnitude, guaranteeing that the photons are sufficiently energetic, but not too energetic.{22}

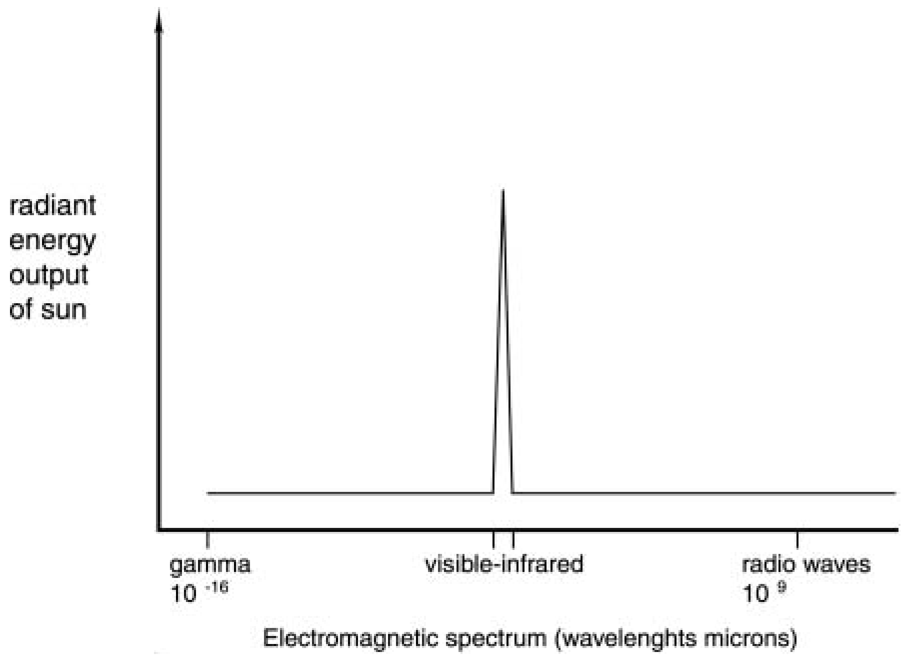
$$m_p^2\ G/[\_\ c]>\sim[e^2/\{\_c\}]^{12}[m_e/m_p]^4 \qquad \textbf{(3)}$$

Substituting the values in Table 2 for h, c, G, m_e, m_p, and e (with units adjusted as required) allows Equation 3 to be evaluated to give:

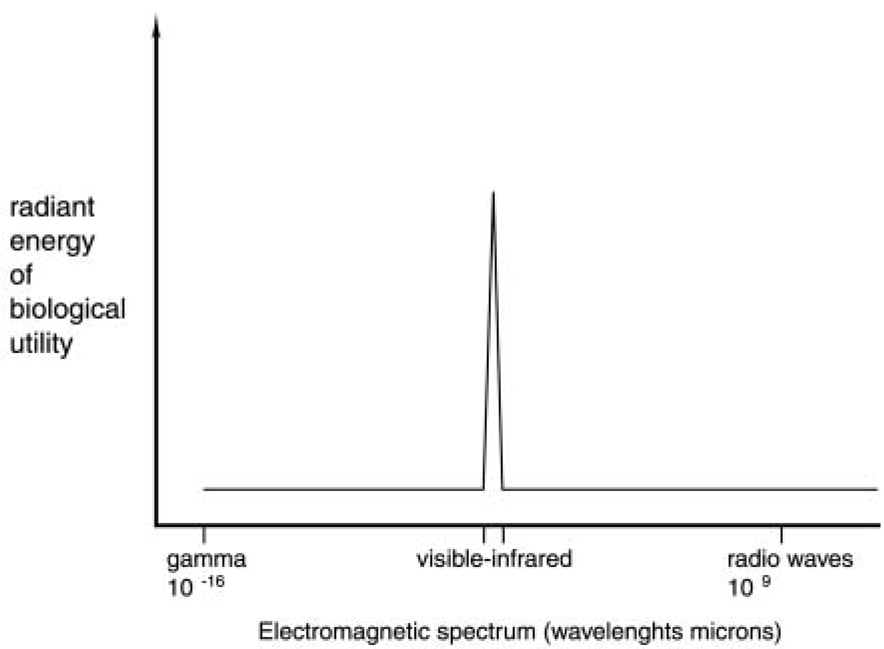
$$5.9 \times 10^{-39} > 2.0 \times 10^{-39} \qquad \textbf{(4)}$$

In what is either an amazing coincidence or careful design by an intelligent Creator, these constants have the very precise values relative to each other that are necessary to give a universe in which radiation from the sun is tuned to the necessary chemical reactions that are essential for life. This result is illustrated in Figure 3, where the intensity of radiation from the sun and the biological utility of radiation are shown as a function of the wavelength of radiation. The greatest intensity of radiation from the sun occurs at the place of greatest biological utility.

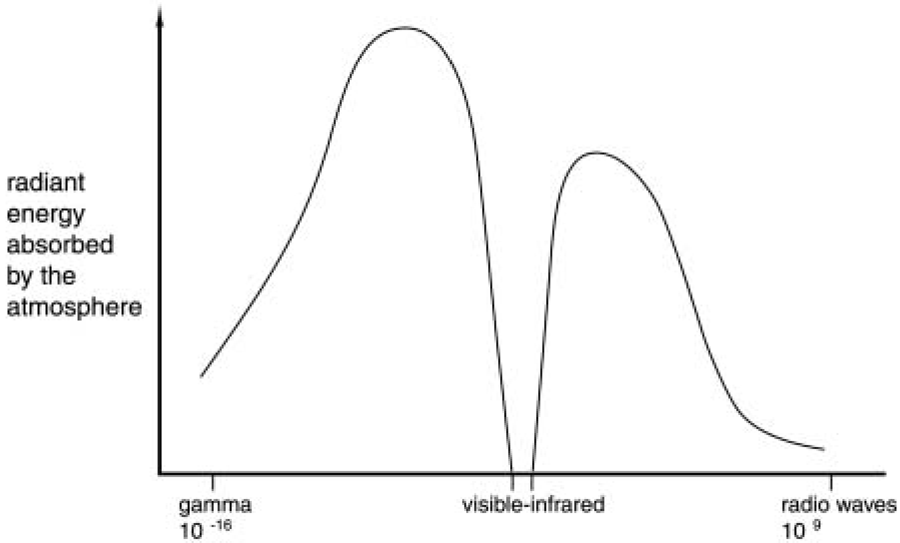
Figure 3.



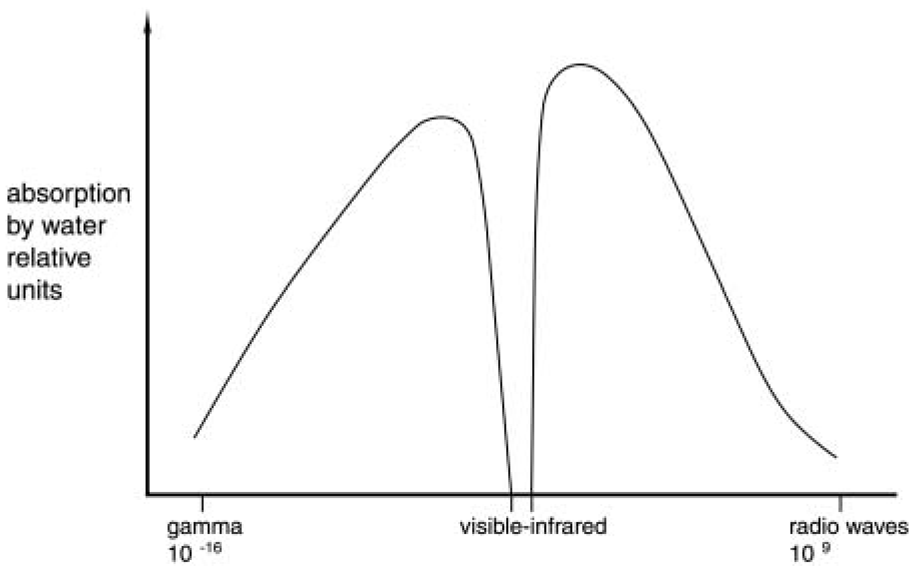
(Figure 3.1.)



(Figure 3.2.)



(Figure 3.3.)



(Figure 3.4.)

Figure 3. The visible portion of the electromagnetic spectrum (~1 micron) is the most intense radiation from the sun (Figure 3.1); has the greatest biological utility (Figure 3.2); and passes through atmosphere of Earth (Figure 3.3) and water (Figure 3.4) with almost no absorption. It is uniquely this same wavelength of radiation that is idea to foster the chemistry of life. This is either a truly amazing series of coincidences or else the result of careful design.

Happily, our star (the sun) emits radiation (light) that is finely tuned to drive the chemical reactions necessary for life. But there is still a critical potential problem: getting that radiation from the sun to the place where the chemical reactions occur. Passing through the near vacuum of space is no problem. However, absorption of light by either Earth's atmosphere or by water where the necessary chemical reactions occur could render life on Earth impossible. It is remarkable that both the Earth's atmosphere and water have "optical windows" that allow visible light (just the radiation necessary for life) to pass through with very little absorption, whereas shorter wavelength (destructive ultraviolet radiation) and longer wavelength (infrared) radiation are both highly absorbed, as seen in Figure 3.{23} This allows solar energy in the form of light to reach the reacting chemicals in the universal solvent, which is water. The *Encyclopedia Britannica*{24} observes in this regard:

Considering the importance of visible sunlight for all aspects of terrestrial life, one cannot help being awed by the dramatically narrow window in the atmospheric absorption...and in the absorption spectrum of water.
It is remarkable that the optical properties of water and our atmosphere, the chemical bonding energies of the chemicals of life, and the radiation from the sun are all precisely harmonized to allow living systems to utilize the energy from the sun, without which life could not exist. It is quite analogous to your car, which can only run using gasoline as a fuel. Happily, but not accidentally, the service station has an ample supply of exactly the right fuel for your automobile. But someone had to drill for and produce the oil, someone had to refine it into liquid fuel (gasoline) that has been carefully optimized for your internal combustion engine, and others had to truck it to your service station. The production and transportation of the right energy from the sun for the metabolic motors of plants and animals is much more remarkable, and hardly accidental.

Finally, without this unique window of light transmission through water, which is constructed upon an intricate framework of universal constants, vision would be impossible and sight-communication would cease, since living tissue and eyes are composed mainly of water.

Nuclear Strong Force and Electromagnetic Force - Finely Balanced for a Universe Rich in Carbon and Oxygen (and therefore water)

The nuclear strong force is the strongest force within nature, occurring at the subatomic level to bind protons and neutrons within atomic nuclei.{25} Were we to increase the ratio of the strong force to the electromagnetic force by only 3.4 percent, the result would be a universe with no hydrogen, no long-lived stars that burn hydrogen, and no water (a molecule composed of two hydrogen atoms and one oxygen atom)--our "universal solvent" for life. Likewise, a decrease of only 9 percent in the strong force relative to the electromagnetic force would decimate the periodic table of elements. Such a change would prevent deuterons from forming from the combination of protons and neutrons. Deuterons, in turn, combine to form helium, then helium fuses to produce beryllium, and so forth.{26}

Within the nucleus, an even more precise balancing of the strong force and the electromagnetic force allows for a universe with an abundance of organic building blocks, including both carbon and oxygen.{27} Carbon serves as the universal connector for organic life and is an optimal reactant with almost every other element, forming bonds that are stable but not too stable, allowing compounds to be formed and disassembled. Oxygen is a component of water, the necessary universal solvent where life chemistry can occur. This is why when people speculate about life on Mars, they first look for signs of organic molecules (ones containing carbon) and signs that Mars once had water.

Quantum physics examines the most minute energy exchanges at the deepest levels of the cosmic order. Only certain energy levels are permitted within nuclei-like steps on a ladder. If the mass-energy for two colliding particles results in a combined mass-energy that is equal to or slightly less than a permissible energy level on the quantum "energy ladder," then the two nuclei will readily stick together or fuse on collision, with the energy difference needed to reach the step being supplied by the kinetic energy of the colliding particles. If this mass-energy level for the combined particles is exactly right, then the collisions are said to have resonance, which is to say that there is a high efficiency within the collision. On the other hand, if the combined mass-energy results in a value that is slightly higher than one of the permissible energy levels on the energy ladder, then the particles will simply bounce off each other rather than fusing, or sticking together.

It is clear that the step sizes between quantum nuclear energy levels depends on the balance between the strong force and the electromagnetic force, and these steps must be tuned to the mass-energy levels of various nuclei for resonance to occur and give an efficient conversion by fusion of lighter element into carbon, oxygen and heavier elements.

In 1953, Sir Fred Hoyle et al. predicted the existence of the unknown resonance energy level for carbon, and it was subsequently confirmed through experimentation.{28} In 1982, Hoyle offered a very insightful summary of the significance he attached to his remarkable predictions.

From 1953 onward, Willy Fowler and I have always been intrigued by the remarkable relation of the 7.65 MeV energy level in the nucleus of 12 C to the 7.12 MeV level in 16 O. If you wanted to produce carbon and oxygen in roughly equal quantities by stellar nucleosynthesis, these are the two levels you would have to fix, and your fixing would have to be just where these levels are actually found to be. Another put-up job? Following the above argument, I am inclined to think so. A common sense interpretation of the facts suggests that a super intellect has "monkeyed" with the physics as well as the chemistry and biology, and there are no blind forces worth speaking about in nature.{29}
The Rest Mass of Subatomic Particles - Key to Universe Rich in Elemental Diversity

Scientists have been surprised to discover the extraordinary tuning of the masses of the elementary particles to each other and to the forces in nature. Stephen Hawking has noted that the difference in the rest mass of the neutron and the rest mass of the proton must be approximately equal to twice the mass of the electron. The mass-energy of the proton is 938.28 MeV and the mass-energy of the neutron is 939.57 MeV. The mass-energy of the electron is 0.51 MeV, or approximately half of the difference in neutron and proton mass-energies, just as Hawking indicated it must be.{30} If the mass-energy of the proton plus the mass-energy of the electron were not slightly smaller than the mass-energy of the neutron, then electrons would combine with protons to form neutrons, with all atomic structure collapsing, leaving an inhospitable world composed only of neutrons.

On the other hand, if this difference were larger, then neutrons would all decay into protons and electrons, leaving a world of pure hydrogen, since neutrons are necessary for protons to combine to build heavier nuclei and the associated elements. As things stand, the neutron is just heavy enough to ensure that the Big Bang would yield one neutron to every seven protons, allowing for an abundant supply of hydrogen for star fuel and enough neutrons to build up the heavier elements in the universe.{31} Again, a meticulous inner design assures a universe with long-term sources of energy and elemental diversity.

The Nuclear Weak Coupling Force - Tuned to Give an Ideal Balance Between Hydrogen (as Fuel for Sun) and Heavier Elements as Building Blocks for Life

The weak force governs certain interactions at the subatomic or nuclear level. If the weak force coupling constant were slightly larger, neutrons would decay more rapidly, reducing the production of deuterons, and thus of helium and elements with heavier nuclei. On the other hand, if the weak force coupling constant were slightly weaker, the Big Bang would have burned almost all of the hydrogen into helium, with the ultimate outcome being a universe with little or no hydrogen and many heavier elements instead. This would leave no long-lived stars and no hydrogen-containing compounds, especially water. In 1991, Breuer noted that the appropriate mix of hydrogen and helium to provide hydrogen-containing compounds, long-term stars, and heavier elements is approximately 75 percent hydrogen and 25 percent helium, which is just what we find in our universe.{32}

This is obviously only an illustrative--but not exhaustive--list of cosmic "coincidences." Clearly, the four forces in nature and the universal constants must be very carefully calibrated or scaled to provide a universe that satisfies the key requirements for life that we enumerated in our initial "needs statement": for example, elemental diversity, an abundance of oxygen and carbon, and a long-term energy source (our sun) that is precisely matched to the bonding strength of organic molecules, with minimal absorption by water or Earth's terrestrial atmosphere.

John Wheeler, formerly Professor of Physics at Princeton, in discussing these observations asks:

Is man an unimportant bit of dust on an unimportant planet in an unimportant galaxy somewhere in the vastness of space? No! The necessity to produce life lies at the center of the universe's whole machinery and design.....Slight variations in physical laws such as gravity or electromagnetism would make life impossible.{33}

Blueprint for a Habitable Universe: The Criticality of Initial or Boundary Conditions

As we already suggested, correct mathematical forms and exactly the right values for them are necessary but not sufficient to guarantee a suitable habitat for complex, conscious life. For all of the mathematical elegance and inner attunement of the cosmos, life still would not have occurred had not certain initial conditions been properly set at certain critical points in the formation of the universe and Earth. Let us briefly consider the initial conditions for the Big Bang, the design of our terrestrial "Garden of Eden," and the staggering informational requirements for the origin and development of the first living system.

The Big Bang

The "Big Bang" follows the physics of any explosion, though on an inconceivably large scale. The critical boundary condition for the Big Bang is its initial velocity. If this velocity is too fast, the matter in the universe expands too quickly and never coalesces into planets, stars, and galaxies. If the initial velocity is too slow, the universe expands only for a short time and then quickly collapses under the influence of gravity. Well-accepted cosmological models{34} tell us that the initial velocity must be specified to a precision of $1/10^{60}$. This requirement seems to overwhelm chance and has been the impetus for creative alternatives, most recently the new inflationary model of the Big Bang.

Even this newer model requires a high level of fine-tuning for it to have occurred at all and to have yielded irregularities that are neither too small nor too large for the formation of galaxies. Astrophysicists originally estimated that two components of an expansion-driving cosmological constant must cancel each other with an accuracy of better than 1 part in 10^{50}. In the January 1999 issue of *Scientific American,* the required accuracy was sharpened to the phenomenal exactitude of 1 part in 10^{123}.{35} Furthermore, the ratio of the gravitational energy to the kinetic energy must be equal to 1.00000 with a variation of less than 1 part in 100,000. While such estimates are being actively researched at the moment and may change over time, all possible models of the Big Bang will contain boundary conditions of a remarkably specific nature that cannot simply be described away as "fortuitous".

The Uniqueness of our "Garden of Eden"

Astronomers F. D. Drake{36} and Carl Sagan{37} speculated during the 1960s and 1970s that Earth-like places in the universe were abundant, at least one thousand but possibly as many as one hundred million. This optimism in the ubiquity of life downplayed the specialness of planet Earth. By the 1980s, University of Virginia astronomers Trefil and Rood offered a more sober assessment in their book, *Are We Alone? The Possibility of Extraterrestrial Civilizations.*{38} They concluded that it is improbable that life exists anywhere else in the universe. More recently, Peter Douglas Ward and Donald Brownlee of the University of Washington have taken the idea of the

Earth's unique place in our vast universe to a much higher level. In their recent blockbuster book, *Rare Earth: Why Complex Life is Uncommon in the Universe,*{39} they argue that the more we learn about Earth, the more we realize how improbable is its existence as a uniquely habitable place in our universe. Ward and Brownlee state it well:

If some god-like being could be given the opportunity to plan a sequence of events with the expressed goal of duplicating our 'Garden of Eden', that power would face a formidable task. With the best of intentions but limited by natural laws and materials it is unlikely that Earth could ever be truly replicated. Too many processes in its formation involve sheer luck. Earth-like planets could certainly be made, but each would differ in critical ways. This is well illustrated by the fantastic variety of planets and satellites (moons) that formed in our solar system. They all started with similar building materials, but the final products are vastly different from each other . . . . The physical events that led to the formation and evolution of the physical Earth required an intricate set of nearly irreproducible circumstances.{40}

What are these remarkable coincidences that have precipitated the emerging recognition of the uniqueness of Earth? Let us consider just two representative examples, *temperature control* and *plate tectonics*, both of which we have alluded to in our "needs statement" for a habitat for complex life.

Temperature Control on Planet Earth

In a universe where water is the primary medium for the chemistry of life, the temperature must be maintained between 0° C and 100° C (32° F to 212° F) for at least some portion of the year. If the temperature on earth were ever to stay below 0° C for an extended period of time, the conversion of all of Earth's water to ice would be an irreversible step. Because ice has a very high reflectivity for sunlight, if the Earth ever becomes an ice ball, there is no returning to the higher temperatures where water exists and life can flourish. If the temperature on Earth were to exceed 100°C for an extended period of time, all oceans would evaporate, creating a vapor canopy. Again, such a step would be irreversible, since this much water in the atmosphere would efficiently trap all of the radiant heat from the sun in a "super-greenhouse effect," preventing the cooling that would be necessary to allow the steam to re-condense to water.{41} This appears to be what happened on Venus.

Complex, conscious life requires an even more narrow temperature range of approximately 5-50° C.{42} How does our portion of real estate in the universe remain within such a narrow temperature range, given that almost every other place in the universe is either much hotter or much colder than planet Earth, and well outside the allowable range for life? First, we need to be at the right distance from the sun. In our solar system, there is a very narrow range that might permit such a temperature range to be sustained, as seen in Fig. 1. Mercury and Venus are too close to the sun, and Mars is too far away. Earth must be within approximately 10% of its actual orbit to maintain a suitable temperature range.{43}

Yet Earth's correct orbital distance from the sun is not the whole story. Our moon has an average temperature of -18° C, while Earth has an average temperature of 33° C; yet each is approximately the same average distance from the sun. Earth's atmosphere, however, efficiently traps the sun's radiant heat, maintaining the proper planetary temperature range. Humans also require an atmosphere with exactly the right proportion of tri-atomic molecules, or gases like carbon dioxide and water vapor. Small temperature variations from day to night make Earth more readily habitable. By contrast, the moon takes twenty-nine days to effectively rotate one whole period with respect to the sun, giving much larger temperature fluctuations from day to night. Earth's rotational rate is ideal to maintain our temperature within a narrow range.

Most remarkable of all, the sun's radiation has gradually increased in intensity by 40 percent over time--a fact that should have made it impossible to maintain Earth's temperature in its required range. This increase, however, has been accompanied by a gradual decrease in the Earth's concentration of carbon dioxide. Today although the Earth receives more radiation, the atmosphere traps it less efficiently, thus preserving approximately the same temperatures that the Earth experienced four billion years ago. The change in the concentration of carbon dioxide over four billion years has resulted first from plate tectonics (by which carbon dioxide has been converted to calcium carbonate in shallow waters), and more recently through the development of plant life. Such good fortune on such a grand scale must be considered a miracle in its own right. But there is still more to the story.

Mercury, Venus, and Mars all spin on their axes, but their axis angles vary chaotically from 0 to 90 degrees, giving corresponding chaotic variations in their planetary climates. Earth owes its relative climatic stability to its stable 23-degree axis of rotation. This unique stability is somehow associated with the size of Earth's large moon. Our moon is one-third the size of Earth--rare for any planet. To have such a large moon is particularly rare for planets in the inner regions of the solar system, where a habitable temperature range can be sustained. The most current theories explaining this proposition lead us again to the suspicion that such a remarkable and "fortuitous accident" occurred specifically for our benefit.{44}

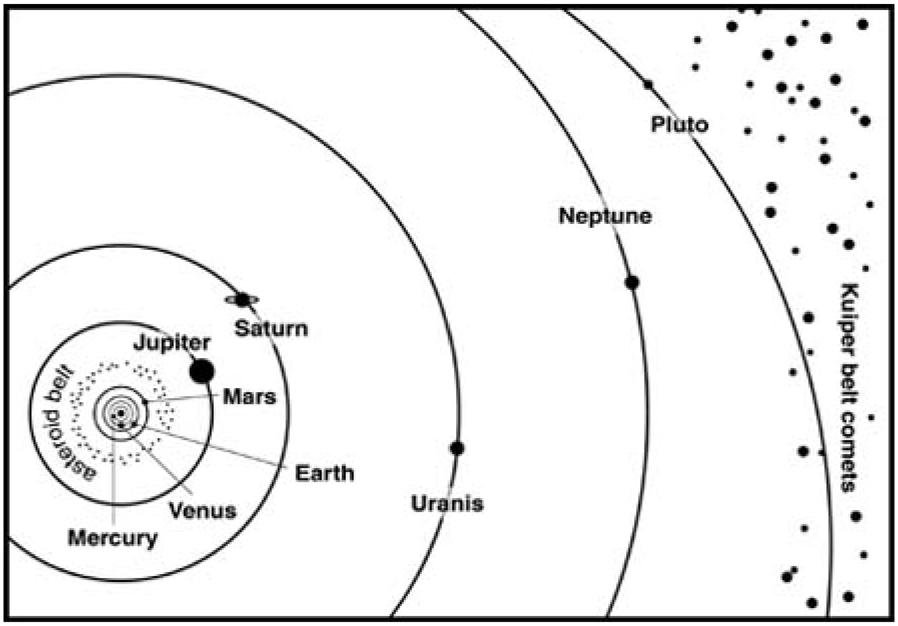


Figure 4. In our solar system (drawn to scale), notice that the habitable zone is the region within ~10 percent of the orbital radius for planet earth, a very small part of our large, solar system.{43}

Plate Tectonics - Continent Builder, Temperature Controller, Cosmic Radiation Protecter

How does plate tectonics contribute to our planet's becoming habitable for complex life? First, plate tectonics have produced a landmass on an earth that would otherwise have remained a smooth sphere covered by 4000 feet of water. Second, plate tectonics on Earth formed regions of shallow water just beyond the landmass. In these shallows, carbon dioxide chemically reacts with calcium silicate to form calcium carbonate and silicon oxide (or sand). This process removes sufficient carbon dioxide from the atmosphere to avoid overheating as the sun's radiant energy increases. Third, plate tectonics allows for sufficiently large thermal gradients to develop the convective cells in the Earth's core that generate our magnetic field, which in turn protects us from cosmic radiation.

It is reasonable to assume that without plate tectonics, no planet could be habitable.{45} Of the 62 satellites in our solar systems, only Earth has plate tectonic activity--a fact that reflects the difficulty to meet the conditions required for this transformational process. Plate tectonics requires just the right concentration of heavy, radioactive elements in a planet or moon's core, in order to produce the proper amount of heat through radioactive decay. Furthermore, the core must be molten, with a solid, but viscous crust. The viscosity of the crust must be carefully calibrated to the heat generation in the core. The total volume of surface water present on a planet is also critical (on Earth, it is 0.5 percent by weight).{46} Too much water will yield a planet with only oceans. Too little water or too much plate tectonic activity will produce a planet with almost all land mass and very small oceans. This imbalance would leave the Earth with a water cycle that could not aerate the landmass adequately to sustain life. The oceans also buffer temperature fluctuations, helping to keep the Earth's surface temperature in a viable range. Earth's current proportion of 30 percent landmass to 70 percent oceans is biologically ideal. However, this complex end result arises from a myriad of factors that appear to be independent. Again, an explanatory model based on "accidents of nature" seems insufficient to account for yet another remarkable feature of our planet.

Blueprint for Life: Information and The Origin of Life

We have not yet touched on the greatest "miracle" in our terrestrial narrative of origins. While we have noted the remarkable provision of a suitable universe with a local habitat that is ideal for life, the most remarkable artifact in our universe is life itself. While biological evolution, including macroevolution, continues to have a larger constituency than is justified by the evidence (in my opinion), all major researchers in the field of chemical evolution (i.e., the origin of life) acknowledge the fundamental mystery of life's beginnings from inanimate matter. The enigma of the origin of life comes in the difficulty of imagining a simply biological system that is sufficiently complex to process energy, store information, and replicate, and yet at the same time is sufficiently simple to have just "happened" in a warm pond, as Darwin suggested, or elsewhere.

Complex molecules, such as proteins, RNA, and DNA, provide for essential biological functions. These biopolymers are actually long chains of simpler molecular building blocks such as amino acids (of which there are 20 different types--see Figure 5), sugars and bases. Their biological function is intimately connected to their precise chemical structure. How, then, were they assembled with such perfect functionality before the origin of life itself? If I stand across the street and throw paint at my curb, I am not very likely to paint "204," which is my house number. On the other hand, if I first place a template with the numbers "204" on my curb and then sling paint, I can easily paint "204" on my curb. Living systems contain their own templates. However, such templates did not guide the process before life began (i.e., under prebiotic conditions). How, then, did the templates and other molecular machinery originate?

To illustrate the staggering degree of complexity involved here, let us consider a typical protein that is composed of 100 amino acids. Amino acids are molecules that can have two mirror image structures, usually referred to as "left-handed" and "right-handed" variants, as seen in Figure 6. A functional protein requires the amino acids from which it is built to be (1) all left-handed; (2) all linked together with peptide bonds (Figure 7), and (3) all in just the right sequence to fold up into the three-dimensional structure needed for biological function, as seen in Figure 8. The probability of correctly assembling a functional protein in one try in a prebiotic pond, as seen in Figure 8, is $1/10^{190}$.{48} If we took all of the carbon in the universe, converted it into amino acids, and allowed it to chemically react at the maximum permissible rate of 10^{13} interactions per second for five billion years, the probability of making a single functioning protein increases to only $1/10^{60}$. For this reason, chance explanations for the origin of life have been rejected. Some non-random process or intelligent designer must be responsible. However, there are no apparent nonrandom processes (such as natural selection is claimed to be in evolution) that would seem to be capable of generating the required complexity and information for the first living system.

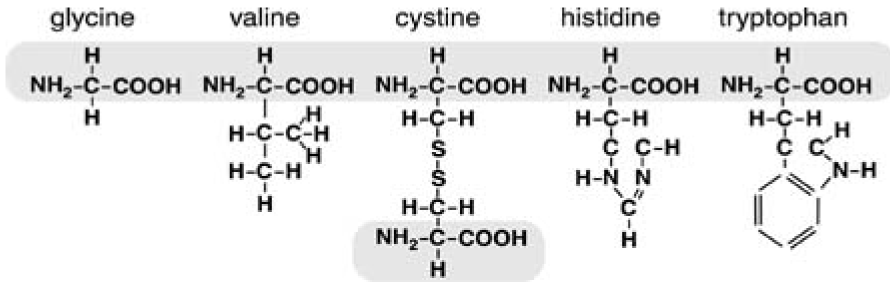


Figure 5. Schematic of five amino acids. Twenty different amino acids are utilized in protein molecules.

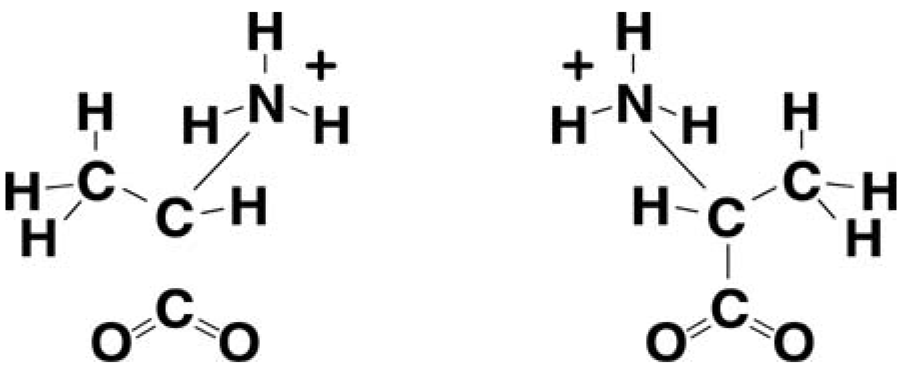


Figure 6. Left- and right-handed versions of amino acids that occur with equal frequency in nature. Only left-handed amino acids are incorporated in protein molecules.

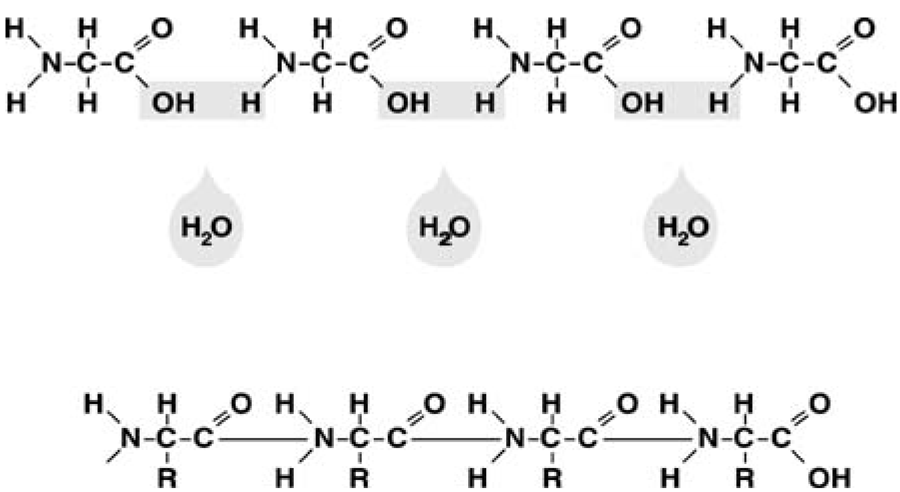


Figure 7. Schematic representation of the formation of peptide bonds with water formed as a byproduct.

Figure 8. Schematic representation of the three-dimensional topography of a chain of amino acids. Note shape is critical to biological function.

Making a viable protein from scratch is analogous to writing a sentence in a language with 20 letters in its alphabet (e.g., distinct amino acids), using a random sequencing of the letters as well as random orientations (that is upside down or sideways). Creating a coherent sentence or short paragraph from such a random sequencing of letters strains the imagination. Creating a functioning living system becomes as arduous as writing a long paragraph with such an inefficient approach. These information-generating requirements present the single, greatest obstacle to a purely naturalistic explanation for the origin of life. Researchers in this field are quick to acknowledge this huge problem. For example, Miller and Levine, in their popular textbook, describes the problem as follows:

The largest stumbling block in bridging the gap between nonliving and living still remains. All living cells are controlled by information stored in DNA, which is transcribed in RNA and them made into protein. This is a very complicated system, and each of these three molecules requires the other two--either to put it together or to help it work. DNA, for example, carries information but cannot put that information to use, or even copy itself without the help of RNA and protein.{47}

One of the giants in origin of life research, Leslie Orgel, in a 1998 review entitled *The Origin of Life - a review of facts and speculations*{48} summarized the current state of affairs with:

There are several tenable theories about the origin of organic material on the primitive earth, but in no case is the supporting evidence compelling. Similarly, several alternative scenarios might account for the self-organization of a self-replicating entity from pre-biotic organic material, but all of those that are well formulated are based on hypothetical chemical syntheses that are problematic.

Nicholas Wade writing in the *New York Times* (6/13/2000){49} about the origin of life notes:
The chemistry of the first life is a nightmare to explain. No one has yet developed a plausible explanation to show how the earliest chemicals of life - thought to be RNA, or ribonucleic acid, a close relative of DNA, might have constructed themselves from the inorganic chemicals likely to have been around on the early earth. The spontaneous assembly of a small RNA molecule on the primitive earth "would have been a near miracle" two experts in the subject helpfully declared last year.
Interested readers are directed to my more detailed treatment of this topic in a book I co-authored entitled *The Mystery of Life's Origin: Reassessing Current Theories.*{50}

Do Discoveries of the Last Fifty Years Support Naturalism or Intelligent Design?

My initial example of design was very simple. It involved one physical law, one universal constant, and two initial conditions. These could easily be prescribed so that my water balloon would arrive on the plaza below the Leaning Tower of Pisa just in time to hit my strolling friend. This was a relatively easy design problem.

A universe that contains a special place of habitation for complex, conscious life is so truly remarkable that it is, realistically speaking, impossible to believe it is the result of a series of cosmic accidents. To choose to believe that there is a naturalistic explanation for (a) the mathematical forms encoded in the laws of nature, (b) the precise specification of the nineteen universal constants and (c) the remarkable initial conditions required for star formation and the simplest living systems is to believe in a miracle by another name. Physicist Freeman J. Dyson of Princeton's Institute for Advanced Study seems to implicitly affirm theism when he say,

"As we look out into the universe and identify the many accidents of physics and astronomy that have worked to our benefit, it almost seems as if the universe must in some sense have known that we were coming."{51}
Physicist and Nobel laureate Arno Penzias, contemplating our enigmatic universe, observes:
Astronomy leads us to a unique event, a universe that was created out of nothing and delicately balanced to provide exactly the conditions required to support life. In the absence of an absurdly improbable accident, the observations of modern science seem to suggest an underlying, one might say, supernatural plan.{52}
Astronomer Sir Fred Hoyle argued in *The Nature of the Universe*{53} in 1950 for the role of sheer coincidence to explain the many unique but necessary properties of the universe and of planet Earth. But the discoveries of the next thirty years dramatically changed his mind, as described in his book *The Intelligent Universe* in 1983; to quote, "Such properties seem to run through the fabric of the natural world like a thread of happy coincidences. But there are so many odd coincidences essential to life that some explanation seems required to account for them."{54}
It is easy to understand why many scientists like Sir Fred Hoyle changed their minds in the past thirty years. They now agree that the universe, as we know it, cannot reasonably

be explained as a cosmic accident. Frederic B. Burnham, a well-known historian of science appearing on ABC's *Nightline with Ted Koppel,* confirmed the current openness to the intelligent design model with his comment,
"The scientific community is prepared to consider the idea that God created the universe a more respectable hypothesis today than at any time in the last 100 years."{55}

Concluding Comments

Returning to the Mt. Rushmore illustration with which we began, we must ask ourselves whether our universe and place in it (planet Earth) are more analogous to Mt. Rushmore or to the rock in Hawaii that captures John F. Kennedy's silhouette in its shadow? It seems to me the answer is perfectly clear, based on the myriad of information presented in this paper and the much larger amount of related information in the literature, that the universe is better represented in its complexity by Mt. Rushmore. However, it is worth noting that Mt. Rushmore is a quite inadequate analogy to our universe and habitat in it.

If a few portions of the Mt. Rushmore monument had been made incorrectly, the impressions of the four presidents would not be completely lost, just less accurate. But, if any one of the five fundamental laws of nature is lacking, if any of the universal constants is outside the permissible range of values, or if any of the many initial conditions is not met, then any potential for life in our universe would be obliterated.

The design requirements for our universe are like a chain of 1000 links. ***If any link breaks, we do not have a less optimal universe for life -- we have a universe incapable of sustaining life!*** The evidence I have present is daunting, but still short of "proof". I must conclude that it takes a great deal more faith to believe in an accidental universe than to believe in an intelligent creator, or God who crafted such a marvelous universe and beautiful place of habitation in planet Earth, and then created life (including human beings) to occupy it.

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{55} ABC's Nightline with Ted Koppel, April 24, 1992.
