ISSN 1522- 5668

Journal of Religion & Society

The Kripke Center Volume 23 (2021)

Ideology in Biology

Theism Meets Atheism in the Case of Abiogenesis

Marc Ruffinengo and Anthony Walsh, Boise State University

Abstract

Abiogenesis is the proposed process through which inanimate matter eventually led to life on earth. As a research area, the issue is certainly loaded with fodder for debate and philosophical and ideological disagreement about what life is and how it came to be. Dealing with the origin of life (OoL) obviously has the potential to tread into spiritual and religious grounds for both scientists interested in this area but also for the public at large when any debate about "where did we come from?" arises. However, it is not just the general public that struggles with balancing religious and spiritual explanations for how people came into being with scientific evidence. As we will show, there is a lively debate among OoL researchers about a similar set of scientific facts pointing to the intervention of a transcendent designer or such an idea being incompatible with science generally. Furthermore, we note that much of this debate is centered around the concepts of ontological and methodological materialism. While we make no claims about resolving or contributing meaningfully to the debate it is worth pointing out, especially to outside observers, that such a debate is in fact alive and well among OoL researchers. Thus, it is certainly possible for OoL researchers to view abiogenesis as an atheistic endeavor and many do. However, atheism is not a requirement to believe that abiogenesis played a role in the OoL as many scientists view such discoveries as a "mark of the Creator" as opposed to merely an idea that life must have come from inanimate matter.

Keywords: ideology, abiogenesis, atheism, theism, thermodynamics

Introduction

Abiogenesis is the hypothetical process by which dead matter is said to have led to life on Earth. Scientists from biology, physics, and chemistry who study this process are known as origin of life (OoL) researchers, and their daunting task is to determine how abiotic chemical evolution could enter the world of the living to become Darwinian biological evolution. This is obviously not a simple task. The gap between non-life and life is the biggest discontinuity in science, and the OoL is the greatest of all scientific problems (Trevors and Abel 2004; Pross and Pascal 2013). Some scientists such as biochemist Jerry Bergman (2000) and biophysicist Dean Kenyon (2002) assert it impossible to solve by any known natural processes, while others, such as chemists Addy Pross and Robert Pascal (2013) maintain that it is, in principle, soluble, although there are aspects of it which we will never know.

The OoL issue is fraught with extra-scientific pronouncements that reveal worldview disagreements rather than purely scientific disagreements. Great scientists are on opposite sides of the barrier as to the deep mystery of life's origin. The present authors are totally incapable of resolving the issue, or even contributing meaningfully to it. Our only goal is to show how ideology intrudes into the issue. By "ideology" we do not mean the dogmatic political left/right divide we see in the human sciences where both sides cherry-pick their facts; we mean philosophical worldviews that impose alternative *meanings* on the same set of undisputed *facts*. We mean it in French philosopher Destutt de Tracy's sense as the study of conflicting ideas: *ideologie* (Van Dijk 2006). Sitting as it does in the middle between the hard physicochemical sciences and the wooly human/social sciences, biology is susceptible to ideology, as Potochnik notes: "Defenders and critics of one or another approach in theoretical biology sometimes employ sweeping, ideologically loaded claims in support of their positions" (2013, 118). An issue as intractable as the OoL is a magnet that is going to stick to a number of different worldviews.

Biology and Ideology

Scientists are trained to identify, explore, and describe the world sustained by empiricism, reason, and logic. They are not supposed to succumb to ways of thinking tainted with emotion, but reason and emotion are fully integrated components of all that we think and do (Pessoa 2008; Suwa et al. 2009). Nowhere is extraordinary reasoning mixed with quite ordinary emotion more in evidence than in ideological battles between scientists. Biology is the science of life, and one basic divide is between biologists that see meaning, purpose, and dignity in life, and those who do not. For instance, meaning, purpose, and human dignity are implicit in physician and geneticist Francis Collins' claim that "God can be found in the cathedral and the laboratory" (2007), while its opposite is explicit in zoologist Richard Dawkins' claim that life is the result of "blind, pitiless, indifference" (1995, 133). In their pre-scientific worldviews—theistic in Collins' case, and atheistic in Dawkins'—it is not their biology that divides them, it is their ideologies, or how they view the same data through different lenses.

Worldviews contain ideas that embody the general principles controlling the coherence of their representations of the data. Scientists in both camps identify, explore, and describe data identically, but their different *explanations*, are guided *metaphysically* by their different visions of ultimate reality. For theists such as Collins, it is a transcendental God, for atheists such as Dawkins, there is no reality beyond the human mind and the matter of the universe, and both are based on faith. We mean "faith" not in Dawkins' view as "blind trust, in the absence of evidence" (1989, 198), but rather in molecular biophysicist Alister McGrath's view that it is intelligent confidence that "commences with the conviction of the mind based on adequate evidence" (2008, 33).

Such divergent ideologies as theism and atheism lead to some emotional and pejorative banging of heads among philosophers and scientists in both camps. For instance, Thomas Nagel admits his emotional attachment to atheism: "I want atheism to be true and am made uneasy by the fact that some of the most intelligent and well-informed people I know are religious believers . . . I don't want there to be a God; I don't want the universe to be like that" (1997, 130). Daniel Dennett, who calls himself and his fellow atheists "brights" as opposed (presumably) to theistic dulls, is pejorative in his statement: "The time has come for us brights to come out of the closet. What is a bright? A bright is a person with a naturalist as opposed to a supernaturalist worldview" (2003). Nobel laureate chemist Christian Anfinsen turns the tables on Dennett to proclaim that: "I think only an idiot can be an atheist. We must admit that there exists an incomprehensible power or force with limitless foresight and knowledge that started the whole universe going in the first place" (quoted in Margenau and Vargese 1997, 139).

From its inception as an academic discipline, biology has been haunted by ideological undercurrents. Because juxtaposing "ideology" as normally understood with "science" sounds oxymoronic, many of us are blind to it, but as Alexander and Numbers state: "So today there is no sign of a let-up in the continuing traffic between biology and ideology" (2010, 10). Ensconced in their labs, biologists pay scant attention to the worldviews that guide their stance toward the big issues that lurk within and beyond their work, so it is left to scholars outside the discipline to point it out to them. The eugenics movement of the early twentieth century is a case in point.

It was not long after the Darwinian revolution that the foundations of social Darwinism and eugenics were laid. The *theory* of social Darwinism was integral to conservative laissez-faire economics, but its *practice* in the form of eugenics was embraced most strongly by socialists and progressives wedded to the ideology of social perfection (Abu El-Haj 2007). Socialist physician Eden Paul opined: "Unless the socialist is a eugenicist as well, the socialist state will speedily perish from racial degradation" (quoted in Paul 1984, 566). Lester Ward, the first president of the American Sociological Society (later, Association) added to this by noting that because "defectives are wards of society," they should be eliminated "completely and as rapidly as possible." (1913, 738). It was the political right that most soundly condemned eugenics on religious grounds (Dikötter 1998). Biologists on both sides of the eugenics issue were scientists, so it was not their science that separated them but rather their moral worldviews – atheism or theism.

Non-Overlapping Magisteria?

There are many people who see science and religion as conflict, others see the two domains as mutually supportive, and others who see them as totally separate domains, and thus cannot be in conflict. The late paleontologist and evolutionary biologist, Stephen J. Gould, was among the latter. He coined the term "non-overlapping magisteria" (NOMA) to refer to his position that science and religion have legitimate authority in their different and non-overlapping domains of inquiry. Since these two magisteria do not overlap, there is no real conflict between science and religion as long as both mind their own business. As Gould put it, "we [scientists] study how the heavens go, and they [theologians] determine how to go to heaven" (1998, 31). Gould was a left-of-center agnostic leaning towards atheism, and thus no apologist for theism.

Non-overlapping magisteria are considered incommensurate domains of knowledge. The terms "incommensurate" and "contradictory" are not synonymous. Two contradictory worldviews, such as the geocentric and heliocentric models of the solar system, can be reconciled with observations because both models speak the same language. Incommensurable worldviews are radical incompatibility in terms of such things as meaning, truth, or justification, because the concepts of one cannot be clearly translated into the concepts of the other. In such a case, the two worldviews cannot logically be compared to expose contradictions, since there is no shared universe of discourse. Other scientists of repute see the two magisteria as intimately connected. For instance, Einstein's familiar statement that "Science without religion is lame, religion without science is blind" (1941) is a case in point. Einstein also said, "The more I study science, the more I believe in God" (quoted in Holt 2018), which implies considerable overlap of Gould's magisteria exists among scientists of great repute. Physicist Own Gingerich also sees overlap, particularly as it applies to the issue of life's origin: "But it is a fallacy that there is no overlap of magisteria. In particular, the fascinating question of how and when we became human inevitably offers an overlap and potentially competing world views" (2014, 98).

The Anthropic Principle

Our aim is to examine issues in abiogenesis research rather than how biology has been applied or misapplied to political, social, or moral issues. When the issues are science *qua* science, the data themselves are not necessarily in question – it is how they are interpreted. It is a short step from interpretation to ask the *meaning* of the data in terms of some ultimate purpose, or to dismiss such ruminations as scientifically meaningless. The concepts of purpose, value, meaning, and final causes were banished from science for much of the twentieth century, but they are quietly returning. Nowhere is this more in evidence than in physics – a discipline that deals with the fundamentals of physical existence. Many great physicists have gone beyond the raw data to ponder the meaning of it all to offer metaphysical critiques.

Questions about purpose and meaning are considered religious rather than scientific, but astrophysicist Paul Davies, who discerns an overlap in Gould's magisteria, writes: "It may seem bizarre, but in my opinion . . . science has actually advanced to the point where what were formerly religious questions can be seriously tackled" (1983, ix). Purpose and meaning in the universe have been both denied and affirmed by scientists, but the greatest of them all, Albert Einstein, believed in a purposeful universe: "The religious inclination lies in the dim consciousness that dwells in humans that all nature, including the humans in it, is in no way an accidental game, but a work of lawfulness that there is a fundamental cause of all existence" (quoted in Isaacson 2007, 46). But what precipitated the modern idea that science could address questions that Davies calls religious questions?

Beginning in the late 1960s, physicists started to ponder the many exquisitely fine-tuned parameters of the universe. Fine-tuning means that the parameters or physical constants of the universe must be adjusted with mind-boggling precision in order for intelligent life to exist.

Many physicists who gave serious thought to this began to believe that what had been termed the cosmological coincidences that make human existence so astronomically improbable are not the result of blind chance, but are rather part of a purposeful universe. This is known as the Anthropic Principle. There are different versions of the principle, beginning with the Weak Anthropic Principle (WAP). The WAP states that, "we must be prepared to take account of the fact that our location in the universe is necessarily privileged to the extent of being compatible with our existence as observers" (Carter 1974, 293). Why would physicists find such an apparent truism as the WAP useful in their daily work?

Physicist Frank Tipler answers this by observing: "But the Weak Anthropic Principle is not trivial, for it leads to unexpected relationships between observed quantities that appear to be unrelated!" (1988, 28). Stephen Hawking says that the "Anthropic Principle is essential, if one is to pick out a solution to represent the universe," and another great physicist, Andrei Linde, opined that "Those who dislike anthropic principles are simply in denial . . . One may hate the Anthropic Principle or love it, but I bet that eventually everyone is going to use it" (quoted in Susskind 2005, 353). Tipler was so impressed by the hundreds of exquisitely fine-tuned parameters that he completely changed his worldview:

> When I began my career as a cosmologist some twenty years ago, I was a convinced atheist. I never in my wildest dreams imagined that one day I would be writing a book purporting to show that the central claims of Judeo-Christian theology are in fact true, that these claims are straightforward deductions of the laws of physics as we now understand them. I have been forced into these conclusions by the inexorable logic of my own special branch of physics. (1994, i)

The Strong Anthropic Principle (SAP) states: "The universe (and thus the fundamental parameters on which it depends) must be such as to admit the creation of observers within it at some stage" (Carter 1974, 294). This statement implies purpose and deliberate design behind human existence. Astrophysicist Luke Barnes also arrived at this conclusion: "The anthropic coincidences are so arresting because we are accustomed to thinking of physical laws and initial conditions as being unconcerned with how things turn out. Physical laws are material and efficient causes [the material from which something is made and the process or agent that makes it], not final causes [the purpose for which it was made]" (2012, 562).

Physicists Barrow and Tipler (1986, 23) then proposed the Final Anthropic Principle (FAP): "Intelligent information-processing must come into existence in the universe, and, once it comes into existence, it will never die out." This sounds all too theistic for some scientists, but to others, such as physicist Josip Planinić, it explains the hundreds of fine-tuned parameters science has discovered: "The anthropic principle, or the fine-tuned universe argument, can also be put forward as a design argument . . . It seems that the universe is arranged (tuned) exclusively to be agreeable to man" (2010, 47). Theoretical physicist Heinz Pagels writes that purposeful design is unattractive to an atheist worldview, and notes: "Faced with questions that do not neatly fit into the framework of science, they are loath to resort to religious explanation; yet their curiosity will not let them leave matters unaddressed. Hence, the anthropic principle. It is the closest that some atheists can get to God" (1985, 38).

There are scientists who dismiss the anthropic principle and its "unnatural" view of the physics of the universe, but as Gingerich points out, Nobel laureate Steven Weinberg has admitted that anthropic explanations for the fine-tuning of the universe cannot be lightly dismissed: "Such crude anthropic explanations are not what we hoped for, but they may have to content us. Physical science has historically progressed not only by finding precise explanations of natural phenomena, but also by discovering what sorts of things *can* be precisely explained. These may be fewer than we thought" (quoted in Gingerich 2015, 142). Weinberg's understanding of the razor's edge balance between dark energy and gravity also lead him to exclaim that: "This is the one fine-tuning that seems to be extreme, far beyond what you could imagine just having to accept as a mere accident" (quoted in Folger 2008). Finally, writing about the discovery of the Higgs boson particle, physicist Harry Cliff tells us that physicists regard the Standard Model as a highly "unnatural" theory because of the large number of particles and forces that are precariously balanced such that changing any of the values "you rapidly find yourself living in a universe without atoms. This spooky fine-tuning worries many physicists, leaving the universe looking as though it has been set up in just the right way for life to exist" (2013).

Ontological Materialism versus Theism

Geneticist Richard Lewontin proclaims that because science has an a priori commitment to materialism it is in a struggle with the supernatural. However, he admits: "It is not that the methods and institutions of science somehow compel us to accept a material explanation of the phenomenal world, but, on the contrary, that we are forced by our a priori adherence to material causes . . . Moreover, that materialism is absolute, for we cannot allow a Divine Foot in the door" (1997). Note that it is Lewontin's faith in materialism, and not the methods of science, that compel him not to accept a "Divine Foot in the door." There are two forms of materialism. The first is *methodologica*l materialism, which does not carry any ideological baggage. As a regulative principle for science, methodological materialism has been enormously successful in broadening our understanding of the universe. All scientists are by necessity methodological materialists regardless of whether they are agnostics, atheists, or theists. No scientist ever introduces a "God term" into his or her equations followed by "then a miracle happens." The most devout of theistic scientists subscribe wholly to methodological materialism because it works, but they reject the notion that the material world exhausts all of reality.

The other form is *ontological* materialism. Ontological materialism goes beyond a working assumption to claim that that science has exclusive access to the truth and is the only way to access reality. It maintains that there is nothing beyond the materialist realm of being, and: "Whatever knowledge is attainable must be attained by scientific methods; and what science cannot discover, mankind cannot know" (Russell 1935, 243). In this view, we should put up the shutters on all university departments other than those falling under the STEM umbrella, because materialistic science is capable of providing comprehensive knowledge of all reality.

Science is the apotheosis of the human spirit, humankind's greatest achievement, but it does not embrace those aspects of reality that give meaning and purpose to life. However, there are scientist who have observed the incredible fine-tuning of the universe, the equally incredible information content of DNA, and intricate nanotechnology of the living cell, and have ventured beyond science in an effort to understand why the universe is the way it is. Many of them are arriving at the position of Nobel Prize winning physicist Joseph J. Thomson that meaning and purpose are indeed found in science: "As we conquer peak after peak we see in front of us regions full of interest and beauty, but we do not see our goal, we do not see the horizon; in the distance tower still higher peaks, which will yield to those who ascend them still wider prospects, and deepen the feeling, the truth of which is emphasized by every advance in science, that 'Great are the Works of the Lord'" (quoted in Walsh 2020, 178).

Unlike methodological materialism, ontological materialism can neither be affirmed or denied by science, and thus is just as metaphysical as theism. Theism affirms a reality beyond matter, which also cannot be conclusively affirmed or denied. Thus, the claim that there is a conflict between science and theism should read that there is a struggle between *ontological* materialism and the supernatural. *Science* is not in conflict with theism, but some *scientists* are. They seem to be in the minority, however. Geneticist Baruch Shalev's (2003) book documenting the religious views of all 719 Nobel Prize winners from 1901 to 2000 found that most were friendly to theism. In fact, only 10.5 percent of these brilliant men and women fell into the atheist, agnostic, or "freethinker" category. Most (35.2%) of the Nobel winners falling into that category were winners in literature; only 4.7 percent of winners in physics did so. This may be the reason prize-wining mathematical physicist Robert Griffiths said, "If we need an atheist for a debate, we go to the philosophy department. The physics department isn't much use" (quoted in Kainz 2010, 21).

The Probability Boundary

The OoL literature abounds with probability statements. Researchers in any scientific discipline are used to accepting or rejecting the null hypothesis at certain levels of statistical confidence. Social science researchers are willing to reject the null at very liberal alpha levels, even at 0.05, but the harder sciences, such as biology, demand at least the 0.001 level (Nielsen and Slatkin 2013). The probabilities of something occurring by chance in the OoL literature are so vanishingly small, that anyone unfamiliar with the literature is astonished when first exposed to them. Given this, it is useful to discuss the probability boundary because many of the probability calculations we encounter vastly exceed it.

Mathematician William Dembski has computed the absolute limit of probability using three estimates from astrophysics: (A) the estimated number of atoms in the known universe (10^{80}), (B) Planck time (10^{45}), and (C) the number of seconds since the Big Bang at the time of his calculations (10^{25}). Planck time sets an absolute limit on the rate at which the properties of elementary particles can transition from one state to another. Dembski concludes: "If we now assume that any specification of an event within the known physical universe requires at least one elementary particle to specify it and that such specifications cannot be generated any faster than the Planck time, then these cosmological constraints imply that the total number of specified events throughout cosmic history cannot exceed $10^{80} \times 10^{45} \times 10^{25} = 10^{150}$" (2004, 84). Dembski's probability boundary exhausts all probability resources since it includes the product of all atoms in the universe, all the seconds since the universe began, and the fastest possible time in which a particle can transition from one form to another.

Abiogenesis: Chemistry becomes Biology

The difficulties attached to the OoL problem may be gauged from the fact that there were 150 theories of the OoL in the literature between 1950 and 2000, and the list keeps growing (Świeżyński 2016). OoL biologists Trevors and Abel note that their colleagues offer little more than long periods of time as an explanation of the OoL, but offer no mechanisms to account for how genetic programming was derived from lifeless atoms bumping around in the dark, and add: "The argument simply says it happened. As such it is nothing more than blind belief" (2004, 736). An example of the "it simply happened" argument is Nobel laureate George Wald's statement that life from non-life is either spontaneous generation or Divine creation, but: "We cannot accept that [Divine creation] on philosophical grounds; therefore, we choose to believe the impossible: that life arose spontaneously by chance!" (1954, 8). Richard Dawkins reveals a similar attitude: "At some point a particularly remarkable molecule was formed by accident. We will call it the Replicator. It had an extraordinary property of being able to create copies of itself. Replicators began not merely to exist, but to construct for themselves containers, vehicles for their continued existence" (1989, 15). Dawkins ignores the problem of how this replicator came into being, and smoothly segues into a discussion of DNA.

All living things possess two things for them to be characterized as such: metabolism and reproductive capacity. To get these things, random inorganic molecules would have to arrange themselves in a very specific and complex way. No one has a clue how this could have happened. Nobel laureate Francis Crick has stated: "An honest man, armed with all the knowledge available to us now, could only state that in some sense, the origin of life appears at the moment to be almost a miracle, so many are the conditions which would have had to have been satisfied to get it going" (quoted in Lim 2017, 58). Another Nobel Prize winner, biochemist Christian de Duve, notes the enormous improbability of "getting it going": "If you equate the probability of the birth of a bacterial cell to that of the chance assembly of its component atoms, even eternity will not suffice to produce one for you" (quoted in Andrews 2017, 248).

The mind-boggling complexities required to give birth to even the simplest self-replicating cell, never mind the membrane to enclose it, present mountains of chicken-or-egg problems. Dean Kenyon, one of the foremost biophysicists of our time, proposed in 1969 that abiogenesis was not only possible, but was inevitable. However, after a 30-year plus career trying unsuccessfully to determine how proteins could self-organize from amino acids, Kenyon came to the conclusion: "We have not the slightest chance of a chemical evolutionary origin for even the simplest of cells . . . so, the concept of the intelligent design of life was immensely attractive to me and made a great deal of sense, as it very closely matched the multiple discoveries of molecular biology" (2002, 35). On the basis of his scientific work, Kenyon abandoned his atheist worldview for a theistic worldview.

Outlines of OoL Research Problems

OoL research was launched in earnest with the 1953 Miller-Urey (Miller 1953) experiment that succeeded in producing a tar-like sludge containing five amino acids. This produced a surge of optimism in the OoL community, but the distance from simple amino acids to functional proteins could be measured in light years. The first major problem confronting

Miller and Urey was that they chose the wrong atmosphere for their experiments. They believed that the early Earth's atmosphere could not have been oxygen-rich as it is today because oxygen interferes with chemical reactions assumed to lead from chemical to biological evolution. They reasoned that the atmosphere must have been "reducing"; that is, one in which little or no oxygen was present because the synthesis of biological molecules can only take place naturally under reducing conditions. Atmospheric scientists now know that the early Earth had an oxygen level close to that of the present: "We can now say with some certainty that many scientists studying the origins of life on Earth simply picked the wrong atmosphere" (DeMarco 2011). Oxygen presents a paradox to OoL scientists because either its presence or absence stymies prebiotic molecule formation. On one hand, the absence of oxygen means no ozone protection (ozone is trioxygen) from deadly ultraviolet rays, and on the other, oxygen's presence interferes with needed chemical reactions (Ward and Brownlee 2000).

Amino acids are monomers which must bond together (polymerize) into large polymer chains to form functioning proteins. OoL scientists once hypothesized that this occurred in an aqueous environment, but it was soon discovered that proteins in water tend to break apart rather than assemble. The bits and pieces destined to end up an RNA molecule must be kept away from water because water is "inherently toxic to polymers (e.g., RNA) necessary for life" (Benner 2014, 342). Astrobiologists Neveu, Kim, and Benner note: "Even the monomers of RNA have problems. In water, deamination reactions convert cytosine to uracil, adenine to hypoxanthine, and guanine to xanthine, in each case destroying information carried by the nucleobase" [the building blocks of RNA and DNA] (2013, 394).

Amino acids do not live, and the fact that they polymerize to make proteins in a specific way presents another problem – the chirality problem. Chiral come from the Greek for "hand." Amino acids come in two forms: D ("dextro") for right-handed, and L for "levo," or left-handed. D and L amino acids are alike in structure and function, but are also distinct from each other because they are mirror-images, just as our hands are. When they are found in nonliving material, or when synthesized in the lab, they come equally in D and L forms – a *racemic* – but a homochiral set of building blocks is necessary for life. All amino acids must be left-handed and all sugars (ribose) must be right-handed to make DNA and RNA. By the laws of nature, chemistry will always produce a racemic (Pross 2012). Thus, the probability of obtaining even a short protein could form from all left-handed monomers is vanishingly small. Astrobiologists Plaxco and Gross do the math and inform us that it "is highly improbable that a random chemistry could produce a polymer molecule that contained monomers of only one-handedness. To be precise, the probability of achieving homochirality in a 189-unit polymer from an equal-molar mixture of left- and right-handed monomers is 1 in 2^{189} (1 in 8 x 10^{56})!" (2006, 114). They add: "The current genetic code seems far more highly optimized than one would expect were it simply an accident." (2006, 129). We should note that a 189-unit polymer is a very small one; some polymers are thousands of amino acids long.

Besides the mind-numbing improbability of achieving homochirality, there are the problems posed by the second law of thermodynamics: "Consider one of the simplest steps in the origin and evolution of life, the choice of one chiral form over racemic mixture. Thermodynamics do not permit this initial step. They dictate full racemization of all non-completely racemic mixtures. In this respect, weak nuclear interactions seemingly do not obey the second law" (Garay 1993, 168). When a physical system reaches its lowest energy state, it is in equilibrium, which by definition means that no further change can occur. Any hypothesized organisms in the prebiotic soup would have had "no internal free energy that would allow them to react further. Life is not just about replication; it is also a coupling of chemical reactions" (Lane, Allen, and Martin 2010, 272). Free energy can only be supplied to a living thing by a mechanism that can harvest energy from the environment in the form of food, water, and sunlight to counteract the decaying effects of the second law; only then can it break free of its shackles. The problem is that a system must already be alive for it to possess such a mechanism.

A further problem confronting OoL research is the problem of chemical reactivity, or how fast a molecule reacts with other molecules. If you have a number of L-amino acids in the lab and allow them to interact unguided, the most reactive acid will link up first and the least reactive acid will line up last. Given the hundreds or thousands of L-amino acids that have to line up in a precise way to get a functional protein, it is no surprise that this never happens without guidance, although it happens every minute of every day guided by the information content of DNA. Organic chemist Charles McCombs informs us that "the polymer chain found in natural proteins and DNA has a precise sequence that does not correlate with the individual components reaction rates" (2004). McCombs goes on to say that amino acids can attach to either end of the chain at random if unguided, and this does not happen without the information in DNA, and if only the laws of physics and chemistry determined the sequence we would not be around it since "the precise sequence by random chemical reactions is unthinkably unlikely" (2004). Relatedly, molecular chemist Steven Benner informs us: "An enormous amount of empirical data have established, as a rule, that organic systems, given energy and left to themselves, devolve to give useless complex mixtures" (2014, 341). Benner lists a number of other paradoxes that "suggest that it is impossible for any non-living chemical system to escape devolution to enter the Darwinian world of the 'living'" (2014, 342).

RNA World and Metabolism First Hypotheses

Another big chicken-or-egg problem confronting OoL scientists is that DNA, RNA, and proteins work as a unit, with DNA storing information, RNA reading it, and proteins doing the necessary enzymatic work. DNA requires enzymes (proteins) to replicate, but these enzymes can only be synthesized by DNA; neither can exist without the other. The probability of this functioning, irreducible whole appearing together by chance is almost beyond calculation, so researchers attempt to determine which came first. Proponents of the RNA World model assert that an RNA molecule must have evolved first since RNA can store genetic information and self-replicate, and it can perform the enzymatic activity of proteins. However, the conundrum here is that RNA contains only raw information, and a blueprint cannot make anything without workers (the ribosomes and other components of a cell), that understand it and can assemble what it represents. Moreover, this gene/enzyme double-duty (function both as a genetic molecule and a catalyst promoting its own replication) presents a paradox because the two roles require contradictory properties. An enzyme, being a protein, must fold into a specific shape and be reactive or it is useless, while RNA carrying information must not do either because it would lose information (Cepelewicz 2017).

Biochemists have succeeded in creating a ribozyme replicase molecule (one that catalyzes its own replication) in the lab. However, the best one created so far in the lab is about 190 nucleotides in length, and is "far too long a sequence to have arisen through any conceivable process of random assembly" (Bernhardt 2012, 7). Bernhardt also notes that it requires between 10^{14} and 10^{16} randomized RNA molecules "as a starting point for the isolation of ribozymic and/or binding activity in *in vitro* selection experiments, completely divorced from the probable prebiotic situation" (2012, 17). Biochemist Charles Kurland is impressed by synthetic ribozymes, but asks: "Why are there no examples of naturally occurring protein-free ribozymes to link the postulated RNA world to the modern cellular world?" (2010, 866). This is not the only problem. The efficiency and fidelity of replication must be sufficient to produce viable copies at a rate exceeding the rate of decomposition of the parent molecule, which is problematic given the inherent instability of RNA. No natural ribozyme has been discovered, and lab-made ribozymes carry out reactions far too slowly (about one-millionth the speed of natural catalysis) to keep up with the degradation of the parent molecule. Others have cast aspersions on the RNA hypothesis, stating that it is "an expression of the infatuation of molecular biologists with base pairing in nucleic acids played out in a one-dimensional space with no reference to time or energy," and thus: "the idea of a 'perfect accident' insinuates itself into the logic of RNA world proponents" (McNichol 2008, 257).

Because of the many difficulties with the RNA model, some OoL scientists have turned to the idea that metabolism evolved first. Metabolism is the mechanism by which all living things circumvent the second law of thermodynamics by harvesting outside energy from the environment. Metabolism converts food into energy to fuel cellular processes, and for it to work there must be a lipid membrane boundary between the inner cell and the outside world which must be sufficiently complex to allow vital elements to enter the cell, and cell products to exit. This is called "compartmentalization." The importance of compartmentalization implies that the cell would have to come before metabolism. What is the point of metabolism unless you have a compartmentalized cell for it to sustain? The membrane is far from a simple sac holding together the contents of the cell. It is a double-layered lipid/protein membrane of astounding complexity, with multiple pores that selectively allow the entry of resources required by the cell and the exit of things needed outside of it (Benner 2014).

The metabolism-first model proposes that the spontaneous formation of a simple primitive cell is assumed to have contained proteins (ignoring the difficulties of making them) that possessed a crude non-genomic replication capacity and subsequent evolution processes led to the accumulation of organic molecules that could serve as catalysts for more complex molecules of RNA and DNA (Gupta, Agogino, and Tumer 2006). However, organic chemist Addy Pross says that the metabolism-first model also runs afoul of the second law of thermodynamics: "How would metabolic cycles form spontaneously from simple molecular entities, and, more importantly, how would they maintain themselves over time? We run yet again into that thermodynamic brick wall" (2012, 107).

We should note that there is a very significant difference between the assembly of atoms and the assembly of organic molecules. When protons and neutrons form a new nucleus the mass of the nucleus is less (0.007%) than the sum of the masses of the particles that constitute it (Penrose 2016). When atoms fuse to form more complex elements, they thus have a lower energy configuration because energy is released in the form of emitted photons (gamma rays) to make the assembled element stable. However, the assembly of organic molecules requires an increase, not a decrease, in energy. Combined organic molecules are inherently unstable and require a constant source of energy to make them stable (Palmer 2013). This is the "thermodynamic brick wall."

Vasas, Szathmáry, and Santos have shown that metabolic systems such as those proposed by metabolism-first proponents are unable to retain information (no genome) about their composition to allow them to evolve toward a metabolic pathway. In other words, they do not contain hereditary information by which they could pass on details of their composition to progeny. Commenting on both the RNA-world and metabolism-first scenarios, they maintain: "Both schools acknowledge that a critical requirement for primitive evolvable systems (in the Darwinian sense) is to solve the problems of information storage and reliable information transmission" (2010, 1470).

Information holds the key to the mystery of the origin of life, argue astrobiologist Sara Walker and astrophysicist Paul Davies: "Although it is notoriously hard to identify precisely what makes life so distinctive and remarkable there is general agreement that its informational aspect is one key property, and perhaps the key property. The manner in which information flows through and between cells and sub-cellular structures is quite unlike anything else observed in nature" (2013, 1). Walker and Davies redefine the OoL problem by shifting from a chemical "hardware" point of view to a "software" information point of view in a phase transition from a bottom-up reductionist chemical processes to one of top-down information flow and management: "The origin of life may thus be identified when information gains top-down causal efficacy over the matter that instantiates it" (2013, 5-6).

Information is non-material, so how can it affect the material? Timo Hannay notes: "Davies claims that life's defining characteristics are better understood in terms of information. This is not as absurd as it may seem. Energy is abstract, yet we have little trouble accepting it as a causal factor" (2019, 428). Although energy is defined as the ability of one physical system to do work on another; we *infer* its existence by its effects, but we do not know what it really *is*. Information is like this; it transfers knowledge of what to do from one system to another, and thus we can define it and affirm its existence without being able to say categorically what it is. In another paper, Walker and Davies think of information this way, and deny that it can be reduced to physics. They talk of the fine-tuning of information and note that if the pathway from chemistry to life is the result of "fixed dynamical laws, then (our analysis suggests) those laws must be selected with extraordinary care and precision, which is tantamount to intelligent design: it states that 'life' is 'written into' the laws of physics *ab initio*. There is no evidence at all that the actual known laws of physics possess this almost miraculous property" (2016, 8).

From Optimism to Pessimism

From this extremely brief presentation of the difficulties confronting OoL research, we see how differing worldviews may intrude when trying to make sense of it. There was considerable optimism after the 1953 Miller-Urey experiment that it would be relatively easy to kick-start life, but over the ensuing 60-odd years optimism has slowly faded to pessimism. The millions of hours spent in experimentation and calculation since Miller-Urey have resulted in a clearer understanding of the immensity of the problem rather than its solution. A huge amount of chemical and biological knowledge has been gained in the process of OoL research, but OoL theories continue to checkmate one another. Even Urey admitted that while he believes in abiogenesis, he does not do so by dint of evidence, but by faith. He remarks: "All of us who study the origin of life find that the more we look into it, the more we feel that it is too complex to have evolved anywhere. But we believe *as an article of faith* that life evolved from dead matter on this planet. It is just that its complexity is so great, that it is hard for us to imagine that it did" (quoted in Persaud 2007, 84; emphasis added). Given that so many scientists have voiced pessimism regarding the natural origin of life on Earth, we briefly examine some ideas they have been put forward as naturalistic alternatives to life originating on earth.

Panspermia as a Naturalistic Alternative to the Improbability of Abiogenesis on Earth

Naturally, scientists would like to accept abiogenesis on empirical evidence rather than on faith alone, just as they do not want to accept a supernatural explanation on faith alone. Both sets of scientists want to base their view on a faith (trust) from a position that "commences with the conviction of the mind based on adequate evidence" (McGrath 2008, 33). Regardless of their religious viewpoint, scientists must search for naturalistic explanations for everything in the natural world. The alternative to a naturalistic origin of life on Earth for theists is supernatural divine creation, but for those who will not let a "Divin**e** foot in the door," the possibilities range from beyond our planet to even beyond our universe. The idea of panspermia ("seeds everywhere") insinuates itself into OoL discussions from time to time.

There are two versions of panspermia – directed and undirected. Undirected panspermia is the notion that life arose somewhere in the vastness of the cosmos and hitched a ride on the millions of comets, meteors, and asteroids that bombarded the early Earth. The exceedingly hostile environment of interstellar space to life led many to dismiss undirected panspermia for directed panspermia. For these scientists, intelligent aliens provided the direction, either by sending protected spores out into the universe with the hope of seeding some suitable planet(s), or that they came to Earth themselves to kick-start life. Among the supporters of this option were Francis Crick and Leslie Orgel (Orgel later disavowed it), who write: "It now seems unlikely that extraterrestrial living organisms could have reached the earth either as spores driven by the radiation pressure from another star or as living organisms imbedded in a meteorite. As an alternative . . . we have considered Directed Panspermia, the theory that organisms were deliberately transmitted to the earth by intelligent beings on another planet" (1973, 341).

Physicists Fred Hoyle and Chandra Wickramasinghe were partial to directed panspermia. They calculated the probability obtaining the necessary enzymes of life and arrived at the conclusion that "there are about two thousand enzymes, and the chance of obtaining them all in a random trial is only one part in $(10^{20})^{2000} = 10^{40,000}$, an outrageously small probability . . . this simple calculation wipes the idea entirely out of court" (1981, 20). Their calculations vastly exceed Dembski's probability boundary, and they were aware that that they had merely moved the origins of life elsewhere, where the same $10^{40,000}$ problem is encountered. This led them to conclude an intelligent control over the process. In Hoyle's *The Intelligent Universe*, he wrote:

> Even after widening the stage for the origin of life from our tiny Earth to the Universe at large, we must still return to the same problem that opened this

> book – the vast unlikelihood that life, even on a cosmic scale, arose from non-living matter. It is apparent that the origin of life is overwhelmingly a matter of arrangement by intelligent control. Unintelligent natural selection is only too likely to produce an unintelligent result (quoted in Korthof 2006).

Hoyle left unanswered the nature of his "intelligent controller," but presumably he/she/they/it was a fully natural intelligent alien being or beings. Of course, the existence of intelligent alien life is confronted with the same huge improbability of how life arose naturalistically on some other planet, so directed panspermia merely pushes the problem back into the vastness of the cosmos just as surely as non-directed panspermia does. No matter where our speculations lead us, we still have to determine how dead matter could enter the living world and eventually lead to intelligent beings who can contemplate the mystery. Taking the problem beyond our planet does not settle the matter for us.

Hoyle had previously made reference to a "super-intellect" in relation to the fusion of carbon atoms in stellar nucleosynthesis in the triple-alpha process. This almost miraculous process that physicists continue to gush over is described in a manner understandable to the layperson in Shaviv (2015). Hoyle predicted the exact energy level for the resonance of helium and beryllium required to manufacture carbon, which is necessary for life. After his prediction was found to be correct, he wrote: "A commonsense interpretation of the facts suggests that a super-intellect has monkeyed with physics, as well as with chemistry and biology, and that there are no blind forces worth speaking about in nature. The numbers one calculates from the facts seem to me so overwhelming as to put this conclusion almost beyond question" (1982, 16). Directed panspermia posits a fully naturalistic intelligent breed of aliens, but such beings could not possibly be the same super-intellect responsible for the mind-boggling triple-alpha process since they obviously could not worm their way into the stars to adjust the parameters of the triple-alpha with such stunning precision. So, who or what is the super-intellect who monkeyed with the physics, chemistry, and biology to which Hoyle referred? Hoyle's colleague, Chandra Wickramasinghe, later abandoned panspermia, or any other naturalistic explanation, for a theistic viewpoint. He wrote: "From my earliest training as a scientist, I was very strongly brainwashed to believe science cannot be consistent with any kind of deliberate creation. That notion has been painfully shed. At the moment I can't find any rational argument to knock down the view that argues for conversion to God . . . Now we realize the only logical answer to life is creation – and not accidental random shuffling" (quoted in Seckbach and Gordon 2009, 343–44). Hoyle and Wickramasinghe were/are brilliant astrophysicists, with Hoyle retaining his atheism and Wickramasinghe abandoning his. They were colleagues and even frequent collaborators, so it was their worldviews and not their science that separated them. Both assumed the impossibility of abiogenesis on Earth, and both appealed to the heavens; one to God and the other to some version of extraterrestrials.

The Multiverse Alternative

Another way to address the astronomical improbability of life emerging from non-life on Earth is to appeal to the idea of a multiverse. The multiverse hypothesis is an attempt to find a non-design explanation for cosmic fine-tuning by positing trillions of other universes that cannot, even in principle, and like God, ever be empirically detected (Ellis and Silk 2014). The argument from design posits that the probability of functional higher-order complexities arising from random step-wise interactions of simple constituent parts is exceedingly low. The probability is enormously higher that such a process will produce only non-functional combinations. We have a finite universe capable of sustaining life, albeit one that is a probabilistic impossible given the trillions of non-life-sustaining alternate values the universal constants could have taken from the Big Bang onwards. Mathematical physicist Roger Penrose calculated what he called "the precision of the Creator's aim" necessary to create a universe consistent with the second law of thermodynamics (the lowest possible entropy) at $10^{10(123)}$ (2016, 445). And that was just to get the whole show on the road. Nevertheless, the multiverse hypothesis allows the design argument to be rejected because, given an infinite number of universes and an infinite amount of time, we have an infinite number of probabilities and the impossible becomes probable, and the probable becomes inevitable. Hypothesize sufficient universes and you are bound to beat the odds against finding one with its physical constants fine-tuned to such an incomprehensible degree as ours.

Physicist Alan Lightman assures us that the multiverse will free us from considering any non-material cause of the fine-tuning necessary to make life possible: "The multiverse offers an explanation of the fine-tuning conundrum that does not require the presence of a Designer" (2011, 38). Lightman is obviously an enthusiastic supporter of the multiverse hypothesis but concedes that it is a conjecture that cannot be proved. Sounding very much like naturalism's pope speaking *ex cathedra*, Lightman concedes that the multiverse hypothesis cannot be proved, but also that all devout ontological materialists *must* take the existence of trillions of unseen and unseeable universes as a matter of faith:

> Not only must we accept that the basic properties of our universe are accidental and incalculable. In addition, we must believe in the existence of many other universes. But we have no conceivable way of observing these other universes and cannot prove their existence. Thus, to explain what we see in the world and in our mental deductions, we must believe in what we cannot prove. (2011, 40)

Evolutionary biologist Eugene Koonin is one who ventures beyond our universe to account for the OoL. Like Hoyle and Wickramasinghe, Koonin calculated the enormous improbability for the simultaneous emergence of translation (the process by which the ribosome uses RNA as a template to make proteins) and replication: "the probability that a coupled translation-replication emerges by chance in a single O-region [observable region of the universe] is 10^{-1018}. Obviously, this version of the breakthrough stage can be considered only in the context of a universe with an infinite (or, in the very least, extremely vast) number of O-regions" (2007, 19). Koonin's calculation is just the probability of getting replication and translation; you still have to get these functions enclosed in a cell with all its complex interdependent parts and get their functioning started. Posit trillions of other universes ("O-regions"), however, and it is back to chance and it is problem solved.

In a book-length examination of the OoL, biochemist Fazale Rana and astrophysicist Hugh Ross reject all naturalistic explanations as beyond the boundary of probability and take a theistic worldview. They maintain that to explain the origin of intelligent species on an alien planet is a bigger problem than explaining it on Earth. So many are the conditions to get life going, they write, that even if the universe "contained as many 10 billion trillion planets, the probability that even one of them would possess all the conditions necessary to support physical life, much less explain its origin, is less than one in 10^{172}" (2004, 206). If correct, this number vastly exceeds Dembski's probability boundary. Appealing to the myriad of fine-tuning discoveries over the past 60 years, Rana and Ross declare: "The data indicate a supernatural origin of life and validate the key assumptions of the [theistic] model – including the involvement of a transcendent Creator" (2004, 208).

Conclusion

We have taken a brief foray into worldviews in biology using as our example the most mysterious of all scientific problems – abiogenesis. The seeming intractability of the problem does nothing to support either theism or atheism, it only demonstrates that both sides base their positions on faith, albeit a faith based on the conviction that the data (or its absence) support their position. On the theistic side, it is faith in a Creator who left the details of creation for science to discover, and on the atheistic side, it is their faith in ontological materialism and in a purposeless universe. Theism and atheism are thesis and antithesis, the latter exists only because the former does. If atheists want theists to provide empirical evidence for the existence of God, then they too should provide empirical evidence that God does not exist if it is to be a valid antithesis. Like the prisoner in the dock, an atheist does not feel it necessary to defend one's position since it is an entirely negative one of simply denying the evidence. Neither side, of course can prove their position scientifically since God is by definition outside of the methods of science.

Theistic scientists make the effort, however, by using the method of abductive reasoning. That is, by looking at multiple lines of evidence from all scientific endeavors and reasoning to the best explanation (Lipton 2000; Meyer 1999). Abductive reasoning is not deductive certainty, but falling back on a courtroom metaphor, it engages the "beyond a reasonable doubt" test, while leaving open the possibility of a different explanation. When theistic scientists ponder the exquisite precision of the initial conditions of the Big Bang, and the exquisite fine-tuning of nature's laws for intelligent life, they see these things as the mark of a transcendent designer. Those with an atheist worldview dismiss this out of hand without offering contrary evidence other than to say "we cannot allow a Divine Foot in the door," or to speculate about a multiverse in which we "must believe," or intelligent aliens who seeded the Earth with life.

Nevertheless, we have seen that all OoL speculations run up against the brick walls of the probability boundary and the second law of thermodynamics. Gifted chemists and biologists continue to pursue a naturalistic explanation of life's origin based on their faith in the cannons of science, as they should. Although atheism requires abiogenesis, it is a mistake to think that abiogenesis research is an atheist-only enterprise. Many theistic scientists are involved in abiogenesis research in the belief that everything science discovers is a fingerprint of God, an attitude put well by Nobel laureate physicist Joseph Taylor: "There is no conflict between science and religion. Our knowledge of God is made larger with every discovery we make about the world" (quoted in Callaway 2018, 19).

Be that as it may, by definition science must look for naturalistic causes. The theistic scientist believes that he or she is exploring secondary causes inherent in matter from the beginning of time placed there by the First Cause – God. If one reads the last chapter of

Darwin's *Origin of Species* in which he writes of "laws impressed on matter by the Creator" (1982, 458), or various letters to friends (e.g., 1892, 61), one sees that this was also his position. Perhaps the theist scientist's position was best articulated by Nobel laureate physicist Erwin Schrodinger: "In the presentation of a scientific problem, the other player is the good Lord. He has not only set the problem but also has devised the rules of the game – but they are not completely known, half of them are left for you to discover or to deduce" (quoted in Moore 1990, 348).

In summary, ideological battles in questions of ultimate reality are between ontological materialists, who are atheists, and those who limit their materialism to methodological materialism, believing there is a spiritual reality as well as a material one. Both sets of scientists reflect and reason about the available evidence (or lack thereof), but like all of us, they reason with built-in biases that lead them to accept or reject the transcendent. Theistic scientists admit that they accept their worldview on faith, but as we have seen, so do atheistic scientists. The conflict between the two ideologies addressed here is about the biggest question of human existence, because it is about existence itself. It would seem inevitable that all thinking people acquire a worldview to help them to make sense of ultimate questions and come down on a position consistent with either that of theist Francis Collins or atheist Richard Dawkins, cited at the beginning of this essay.

Bibliography

Abu El-Haj, N. 2007. "The Genetic Reinscription of Race." *Annual Review of Anthropology* 36: 283–300.

Alexander, D. R., and R. L. Numbers, eds. 2010. *Biology and Ideology from Descartes to Dawkins*. Chicago: University of Chicago Press.

Andrews, E. 2017. *Is the Bible Really the Word of God? Is Christianity the One True Faith?* Cambridge: Christian Publishing House.

Barnes, L. 2012. "The Fine-Tuning of the Universe for Intelligent Life." *Publications of the Astronomical Society of Australia* 29: 529–64.

Barrow, J., and F. C. Tipler. 1986. *The Anthropic Cosmological Principle*. New York: Oxford University Press.

Benner, S. 2014. "Paradoxes in the Origin of Life." *Origins of Life and Evolution of Biospheres* 44: 339–43.

Bergman, J. 2000. "Why Abiogenesis is Impossible." *Creation Research Society Quarterly* 36: 1–17.

Bernhardt, H. 2012. "The RNA World Hypothesis: The Worst Theory of the Early Evolution of Life (Except for all the Others)." *Biology Direct* 7: 1–10.

Callaway, M. 2018. *Crossroads of the Eternal*. Eugene: Resource Publishers.

Carter, B. 1974. "Large Number Coincidences and the Anthropic Principle in Cosmology. IAU 63, *Confrontation of Cosmological Theories with Observational Data* 63: 291–98.

Cepelewicz, J. 2017. "Life's First Molecule was Protein, Not RNA, New Model Suggests." *Quanta Magazine* 12. https://www.quantamagazine.org/lifes-first-molecule-was-protein-not-rna-new-model-suggests-20171102.

Cliff, H. 2013. "Could the Higgs Nobel be the End of Particle Physics? *Scientific American*. (October 8). https://www.scientificamerican.com/article/could-the-higgs-nobel-be-the-end-of-particle-physics.

Collins, F. 2007. "Collins: Why This Scientist Believes in God." *CNN News*. http://www.cnn.com/2007/US/04/03/collins.commentary/index.html.

Crick, F., and L. Orgel. 1973. "Directed Panspermia." *Icarus* 19: 341–46.

DeMarco, G. 2011. "Setting the Stage for Life: Scientists Make Key Discovery about the Atmosphere of Early Earth." *Rensselaer News*. https://news.rpi.edu/luwakkey/2953.

Darwin, C. 1892. *Charles Darwin: His Life Told in an Autobiographical Chapter, and in a Selected Series of His Published Letters*, vol. 5, edited by F. Darwin. London: John Murray.

———. 1982. *The origin of species*. London: Penguin.

Davies, P. 1983. *God and the New Physics*. New York: Penguin.

Dawkins, R. 1989. *The Selfish Gene*. Oxford: Oxford University Press.

———. 1995. *River Out of Eden: A Darwinian View of Life*. New York: HarperCollins.

Dembski, W. 2004. *The Design Revolution: Answering the Toughest Questions About Intelligent Design*. Westmont: InterVarsity.

Dennett, D. 2003. "The Bright Stuff." *New York Times* (July 12). https://www.nytimes.com/2003/07/12/opinion/the-bright-stuff.html.

Dikötter, F. 1998. "Race Culture: Recent Perspectives on the History of Eugenics." *The American Historical Review* 103: 467–78.

Einstein, A. 1941. Science, Philosophy and Religion, A Symposium. *The Conference on Science, Philosophy and Religion in Their Relation to the Democratic Way of Life, Inc.*, New York.

Ellis, G., and J. Silk. 2014. "Scientific Method: Defend the Integrity of Physics." *Nature* 516: 321–23.

Folger, T. 2008. "Science's Alternative to an Intelligent Creator: The Multiverse Theory. *Discover Magazine* (December 10). http://discovermagazine.com/2008/dec/10-sciences-alternative-to-an-intelligent-creator.

Garay, A. 1993. "Theoretical and Experimental Studies of the Possibility of Chirality Dependent Time Direction in Molecules." In *Chemical Evolution: Origin of Life*, edited by C. Ponnamperuma and J. Chela-Flores, 165–79. Hampton: Deepak.

Gingerich, O. 2014. *God's Planet*. Cambridge,: Harvard University Press.

Gould, S. 1998. *Leonardo's Mountain of Cams and the Diet of Worms*. London: Jonathan Cape.

Gupta, N., A. Agogino, and K. Tumer. 2006. "Efficient Agent-Based Models for Non-Genomic Evolution." In *Proceedings of the Fifth International Joint Conference on Autonomous Agents and Multiagent Systems*, 58-64. ACM.

Hannay, T. 2019. "Life Versus Entropy." *Science* 565: 427–28.

Holt, J. 2018. *When Einstein Walked with Gödel: Excursions to the Edge of Thought*. New York: Farrar, Straus and Giroux.

Hoyle, F. 1982. "The Universe: Past and Present Reflections." *Annual Review of Astronomy and Astrophysics* 20: 1–36.

Hoyle, F., and C. Wickramasinghe. 1981. *Evolution from Space*. London: J. M. Dent.

Isaacson, W. 2007. *Einstein: His Life and Universe*. New York: Simon and Schuster.

Kainz, H. P. 2010. *The Existence of God and the Faith-Instinct*. Selinsgove: Susquehanna University Press.

Kenyon, D. 2002. *Unlocking the Mystery of Life*, Script. http://www.divinerevelations.info/documents/intelligent_design/unlockingthemysteryoflifescript.pdf.

Koonin, E. 2007. "The Cosmological Model of Eternal Inflation and the Transition from Chance to Biological Evolution in the History of Life." *Biology Direct* 2: 1–21.

Korthof, G. 2006. "Fred Hoyle's *The Intelligent Universe*: A Summary & Review." http://wasdarwinwrong.com/kortho47.htm.

Kurland, C. 2010. "The RNA Dreamtime." *Bioessays*, 32: 866–71.

Lane, N., J. Allen, and W. Martin. 2010. "How Did LUCA Make a Living? Chemiosmosis in the Origin of Life. *BioEssays* 32: 271–80.

Lewontin, R. 1997. "Billions and Billions of Demons." *New York Review of Books* (January 9).

Lightman, A. 2011. "The Accidental Universe: Science's Crisis of Faith. *Harper's Magazine* (December).

Lim, R. 2017. *Self and the Phenomenon of Life: A Biologist Examines Life from Molecules to Humanity*. Hackensack: World Scientific.

Lipton, P. 2000. "Inference to the Best Explanation." In *A Companion to the Philosophy of Science*, edited by W. Newton-Smith, 184–93. Hoboken, NJ: Blackwell.

Margenau, H., and R. Varghese. 1997. *Cosmos, Bios, Theos: Scientists Reflect on Science, God, and the Origins of the Universe, Life, and Homo sapiens*, Fourth edition. Chicago: Open Court.

McCombs, C. 2004. "Evolution Hopes You Don't Know Chemistry: The Problem of Control." *Acts & Facts* 33, 8. https://www.icr.org/article/evolution-hopes-you-dont-know-chemistry-problem-co.

McGrath, A. 2008. *The Order of Things: Explorations in Scientific Theory*. New York: John Wiley & Sons.

McNichol, J. 2008. "Primordial Soup, Fool's Gold, and Spontaneous Generation." *Biochemistry and Molecular Biology Education* 36, 4: 255–61.

Meyer, S. 1999. "The Return of the God Hypothesis." *Journal of Interdisciplinary Studies* 11: 1–31.

Miller, S. 1953. "A Production of Amino Acids under Possible Primitive Earth Conditions." *Science* 117: 528–29.

Moore, W. 1990. *Schroedinger: Life and Thought*. Cambridge, Cambridge University Press,

Nagel, T. 1997. *The Last Word*. New York: Oxford University Press.

Neveu, M., H. Kim, and S. Benner. 2013. "The 'strong' RNA World Hypothesis: Fifty Years Old. *Astrobiology* 13: 391–403.

Nielsen, R., and M. Slatkin. 2013. *An Introduction to Population Genetics: Theory and Applications*. Sunderland: Sinauer Associates.

Paul, D. 1984. "Eugenics and the Left." *Journal of the History of Ideas* 45: 567–90.

Pagels, H. 1985. "A Cozy Cosmology." *The Sciences* 25: 34–38.

Palmer, B. 2013. "A Review on the Spontaneous Formation of the Building Blocks of Life and the Generation of a Set of Hypotheses Governing Universal Abiogenesis." *International Journal of Astrobiology* 12: 39–44.

Penrose, R. 2016. *The Emperor's New Mind: Concerning Computers, Minds, and the Laws of Physics*. New York Oxford University Pres.

Persaud, C. 2007. *Evolution: Beyond the Realm of Real Science*. Maitland: Xulon.

Pessoa, L. 2008. "On the Relationship between Emotion and Cognition." *Nature/Neuroscience* 9: 148–58.

Planinić, J. 2010. "The Design Argument – Anthropic Principle." *Journal of Philosophy and Religious studies* 65: 47–54

Plaxco, K., and M. Gross. 2006. *Astrobiology: A Brief Introduction*. Baltimore: Johns Hopkins University Press.

Potochnik, A. 2013. "Defusing Ideological Defenses in Biology." *BioScience* 63: 118–23.

Pross, A. 2012. *What is Life? How Chemistry Becomes Biology*. Oxford: Oxford University Press.

Pross, A., and R. Pascal. 2013. "The Origin of Life: What We Know, What We can Know and What We will Never Know." *Open Biology* 3: 120190.

Rana, F., and H. Ross. 2004. *Origins of Life*. Colorado Springs: NavPress.

Russell, B. 1935. *Religion and Science*. New York: Oxford University Press.

Seckbach, J., and R. Gordon. 2009. *Divine Action and Natural Selection: Science, Faith and Evolution*. Hackensack: World Scientific.

Shalev, B. 2003. *Religion of Nobel Prize winners. 100 years of Nobel prizes*. New Delhi: Atlantic.

Shaviv, G. 2015. "Who Discovered the Hoyle Level?" *Acta Polytechnica CTU Proceedings* 2: 311–20.

Susskind, L. 2005. *The Cosmic Landscape: String Theory and the Illusion of Intelligent Design*. New York: Little, Brown and Company.

Suwa, G., B. Asfaw, R. Kono, D. Kubo, C. Lovejoy, and T. White. 2009. "The *Ardipithecus Ramidus Skull* and Its Implications for Hominid Origins." *Science* 326:68e1-68e8.

Świeżyński, A. 2016. "Where/When/How did Life Begin? A Philosophical Key for Systematizing Theories on the Origin of Life." *International Journal of Astrobiology* 15: 291–99.

Tipler, F. J. 1988. "The Anthropic Principle: A Primer for Philosophers." *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association* 1988: 27–48.

———. 1994. *The Physics of Immortality: Modern Cosmology, God, and the Resurrection of the Dead*. New York: Anchor.

Trevors, J., and D. Abel. 2004. "Chance and Necessity Do Not Explain the Origin of Life." *Cell Biology International* 28: 729–39.

Van Dijk, T. 2006. "Ideology and Discourse Analysis." *Journal of Political Ideologies* 11: 115–40.

Vasas, V., E. Szathmáry, and M. Santos. 2010. "Lack of Evolvability in Self-Sustaining Autocatalytic Networks Constraints Metabolism-First Scenarios for the Origin of Life." *Proceedings of the National Academy of Sciences* 107: 1470–75.

Wald, G. 1954. "The Origin of Life." *Scientific American*, 191: 45–53.

Walker, S., and P. Davies. 2013. "The Algorithmic Origins of Life." *Journal of the Royal Society Interface* 10: 20120869.

———. 2016. "The 'Hard Problem' of Life." *arXiv*: 1606.07184.

Walsh, A. 2020. *God, Science, and Society: The Origin of the Universe, Intelligent Life, and Free Societies*. Wilmington. Vernon

Ward, L. 1913. "Eugenics and Eudemics." *American Journal of Sociology*, 18: 737–54.

Ward, P., and D. Brownlee. 2000. *Rare Earth: Why Complex Life is Uncommon in the Universe*. New York: Copernicus Books.