

## How Does the BioLogos Model Need to Address Concerns Christians Have About the Implications of its Science?

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### ABSTRACT

Many barriers to the acceptance of the BioLogos model by evangelical Christians arise from popular misconceptions about the nature of science and its relationship to God's action in our world. These misconceptions mirror those held by the general public (and are regularly exploited by the new atheists).

For example, difficulties result from conflating “mechanism” and “meaning”. Thus claims that the biological complexity around us arose through regular physical processes often smell like deism or even atheism to the average person in our pews. A second set of issues clusters around popular views of natural theology where the waters are further muddied by the misuse of value-laden metaphoric language (e.g. “random” and “selfish gene”) to describe biological evolution. Finally, difficulties also arise from questions of authority: Who can a Christian trust to judge the reliability and implications of new scientific findings?

This essay will argue that to overcome these obstacles BioLogos should:

- 1) Draw on the robust biblical theme that God sustains the world and the rich tradition of theological reflection on the difference between God's *regular* and *miraculous* acts.
- 2) Carefully delineate the limits of natural theology, and develop a more nuanced set of metaphors to describe the emergence of biological complexity.
- 3) Sensitively mediate between the community of Christian academic scientists, the Christian laity and the general public.

### INTRODUCTION

*This most beautiful system of the sun, planets, and comets could only proceed from the counsel and dominion of an intelligent and powerful Being.*

- Sir Isaac Newton. *Principia Mathematica* (1687)

Perhaps the most spectacular early success of Isaac Newton's theory of gravitation was its natural explanation for Johannes Kepler's observation that the planets orbit the sun in elliptical orbits. But upon further reflection, some nagging problems emerge. The perfect elliptical orbits are only valid for an isolated planet orbiting around the sun. Gravity works on all objects, and so the other planets perturb the motion of the Earth, potentially leading to its ejection from the solar system. This problem vexed Sir Isaac, who postulated that God occasionally “reformed” the planets, perhaps by sending through a comet with just the right trajectory.



Many difficulties that evangelical Christians have with the science of the BioLogos model are caused not so much by evolutionary biology itself (the visible part of the “iceberg”), but rather by unrecognized assumptions that may lie deep under the surface. These submerged issues include popular notions of how God acts in the world (divine action), rationalistic natural theologies, misunderstood metaphors, and questions about who Christians should trust in the academy.

In a famous exchange of letters, cut short only by his death in 1716, Gottfried Wilhelm Leibniz took Sir Isaac to task for his view. He objected that:

*if God had to remedy the defects of His creation, this was surely to demean his craftsmanship.<sup>1</sup>*

And moreover that:

*..when God works miracles, he does it not to meet the needs of nature but the needs of grace. Anyone who thinks differently must have a very mean notion of the wisdom and power of God.<sup>2</sup>*

In other words, the regular sustaining activity of God, as evidenced by natural laws, should be sufficient to explain the regular behavior of the solar system, without the need for additional ad-hoc interventions. Making it right the first time is more glorious than having to fix it later. Moreover, when God deviates from his regular sustaining activity to perform miracles, he does so for soteriological reasons, not to repair nature.

When I present this story to an evangelical Christian audience, most side with Leibniz: they agree that it is indeed more glorious if God doesn't need to occasionally reform the planets. A good many will grant me that Leibniz's point on miracles is consistent with the Bible. But if I try to push the analogy further and suggest that it could be more glorious for God to create the rich biological diversity we observe around us through a continuous evolutionary process, rather than by episodic "intervention", my audience is typically much more skeptical. And I have some sympathy for their apprehension. Living beings impinge more closely on theology than planets do.

This response to the Leibniz-Newton exchange encapsulates many of the main themes of this essay. While theological concerns about evolution and how it relates to the fall and Adam are tremendously important, I will argue that other factors also play a key role in the resistance of many Christians towards evolutionary science. Like the proverbial iceberg, these issues lie submerged beneath the surface and will sink discussions about evolution unless they are recognized.

The first cluster of submerged issues surrounds the nature of science and God's action in the world. In popular culture, a scientific explanation of the physical mechanisms by which a process occurs is often privileged as the primary source of meaning and purpose -- e.g. "we used to think that God created the world, but now we know that it was the Big Bang".<sup>3</sup> Furthermore, even among Christians, the influence of modern concepts like a semi-independent Nature lead to the expectation that God mainly acts by supernatural intervention in the physical world. Thus the worry arises that if a comprehensive scientific account of a process can be obtained, God's power and presence are diminished.

The second cluster of issues arises from popular views of natural theology. Despite warnings from great thinkers such as Pascal, Newman and Barth<sup>4</sup>, the idea that an unbiased observer should be able to use science to find unambiguous evidence for God's existence is remarkably resilient among Christians. Furthermore, many attempts at natural theology rely heavily on value-laden metaphors that come from popularizations of science. This cuts both ways. On the one hand Archdeacon Paley saw the hand of God in the intricate watch-like "contrivances of nature"<sup>5</sup>, while on the other hand Richard Dawkins sees a pitiless and indifferent "blind watchmaker"<sup>6</sup> in what he believes are the wasteful and purposeless processes of

evolution. Although their conclusions couldn't be more different, both are engaging in a natural theology based on similar rationalistic assumptions.

It would greatly facilitate the in-house Christian conversation about evolution if we could loosen the grip of these modernist versions of natural theology. Nevertheless, metaphors do matter. I think that is why my audiences are reasonably happy with a God who places the planets in stable orbits without further intervention, while they are much less comfortable with a God who uses evolution, for which popular descriptions use morally loaded words like chance, random, purposeless and survival of the fittest. I will argue that these popular metaphors may not be the best ways to describe the richness of current evolutionary theory.

The final cluster of issues concerns the critical problem of trust and the world of higher learning. How Christians should relate to the full spectrum of ideas surrounding modern biological evolution is a complex question that needs expert input from geologists, chemists, biologists, philosophers, historians, theologians and perhaps even physicists. Should Christians rely on individuals they trust or can these kinds of questions only be addressed by communities of scholars? Here I am heavily influenced by Mark Noll's prophetic book, *The Scandal of the Evangelical Mind*, Eerdmans (1994). He points out that although Evangelicals exhibit an extraordinary range of virtues, careful engagement with the intellectual world is not usually one of them. This is curious because modern Evangelicals descend from "*leaders and movements distinguished by probing, creative, fruitful attention to the mind.*"

Moreover,

*If Evangelicals are the ones who insist most aggressively that they believe in sola scriptura, and if Evangelicals are the ones who assert most vigorously the transforming work of Jesus Christ, then it is reasonable to hope that what the Scriptures teach about the origin of creation in Christ, the sustaining of all things in Christ, and the dignity of all creation in Christ -- about, in other words, the subjects of learning -- will be a spur for Evangelicals to a deeper and richer intellectual life: "He is before all things, and in him all things hold together" (Colossians 1:15-17).<sup>7</sup>*

'In him all things hold together': how can BioLogos help our brothers and sisters in Christ to explore how this confession relates to what science has discovered about the origins of the biological complexity we see around us?

## SCIENCE AND THE BIBLE

*The Son is the radiance of God's glory and the exact representation of his being, sustaining all things by his powerful word.*

- Hebrews 1:3

*Are not two sparrows sold for a penny? Yet not one of them will fall to the ground apart from the will of your Father. And even the very hairs of your head are all numbered. So don't be afraid; you are worth more than many sparrows.*

- Matthew 10:29-31

The Bible opens with a glorious account of the one almighty God who has only to speak and the world comes into being. These early chapters of Genesis lay down themes that are expanded and elaborated in the many other biblical creation passages.<sup>8</sup> A message we moderns may not pick up on so easily is illustrated by literary devices such as using the words “greater lamp” and “lesser lamp” instead of the usual Hebrew words to refer to the sun and the moon and moreover relegating them (together with the stars almost as an “afterthought”) to the fourth day.<sup>9</sup> Why was this done? Almost certainly because the people of Israel were tempted to worship the sun and moon. Declaring that these heavenly bodies were physical objects rather than beings who control our lives may seem unremarkable to our modern ears, but it would have sounded incredibly daft to the intelligentsia of the day, who were, after all, astrologers.

Today the dominant assumption among the intelligentsia is very different, namely an autonomous “mother nature” that runs on its own. If there is a God, then they feel he should show himself by intervening — “poking into” — that world. These same influences lead Christians down blind apologetic alleys like arguing for a “God of the gaps”.<sup>10</sup> This modern Christian temptation has its roots in the same heresy as the one that plagued the ancients: a misunderstanding of the sovereignty of God over all creation.

Our modern concept of “Nature” as an entity independent of God cannot be found in the Bible. Instead, the creation passages emphasize a God who “*sustain[s] all things by his powerful word*” (Heb 1:3). That is why, for example in Psalm 104, the point of view fluidly changes back and forth from direct action by God — “*He makes springs pour water into ravines*” — to water acting on its own — “[*the water*] flows down the mountains”. Such dual descriptions are two different perspectives of the same thing. Within a robust biblical theism, if God were to stop *sustaining all things*, the world would not slowly grind to a halt or descend into chaos; it would simply stop existing.

So how should we think about science then? Certainly modern science was not present at the time that the Bible was written. It is a good hermeneutical principle that God inspired the biblical authors to write within the confines of their own culture.<sup>11</sup> So to first order the Bible is not directly concerned with the practice of modern science. Nevertheless there are principles that can be brought to bear. Out of a rich theological tradition of reflection on the difference between God’s miraculous acts and his regular sustenance of nature the following ideas emerge: If the regularities of nature are a manifestation of the faithful sustenance of an eternal and unchanging God then one would expect them to be trustworthy and consistent. The regular behavior of nature could be viewed as the “customs of the creator”. Christians glorify God by studying these “laws of nature.” A strong case can be made that such theological realizations helped pave the way for the rise of modern science itself.<sup>12</sup>

By the time the Royal Society of London, the world’s first scientific society, was founded in 1660, Christian thinkers like the poet John Donne, then Dean of St. Paul’s Cathedral in London, could write:

*the ordinary things in Nature, would be greater miracles than the extraordinary, which we admire most, if they were done but once... only the daily doing takes off the admiration.*<sup>13</sup>

These theological principles naturally explain why one might expect the universe to exhibit properties like uniformity, rationality and intelligibility that undergird science. It is less clear how to justify these metaphysical principles from a purely naturalistic framework.<sup>14</sup>



What about miracles then?<sup>15</sup> It is important to remember that they are not just “wonders” (teras) for us to marvel at, but signs (semion) or works of power (dunamis). They occur when, to achieve his divine purposes, God chooses to sustain the world in a manner that is different from the way he normally does.

We thus see that within the biblical framework of a God who faithfully sustains the world we have good reason to expect that:

- 1) The scientific method will have success in describing the “customs of the creator”, that is, the regular ways that God interacts with and sustains the world.
- 2) God can also interact in less customary ways and do miracles, but since we do not have full access to the divine mind, we cannot know or control all the conditions, nor repeat them. Thus by definition they fall outside of the remit of science. You could almost say that the Bible teaches that miracles are unscientific (although of course science could measure their consequences).<sup>16</sup>

This brings us back to Leibniz’s two criticisms of Newton. Strictly speaking, the first one -- that it demeans God’s craftsmanship if he has to intervene in nature -- cannot be directly derived from the Bible. God is free; he can sustain the universe in whatever way he pleases. Nevertheless the sentiment behind this critique builds on a venerable theological tradition of the eternal and unchanging God faithfully sustaining the world in a regular way.

The second criticism – that God doesn’t do miracles to satisfy the wants of nature, but rather those of grace – builds on the more explicit Biblical theme that God performs miracles for his divine purposes. Fundamentally, the question of whether God did or did not use miracles in natural history is only accessible to us through revelation.<sup>17</sup> Most commentators would say that the creation passages, rich though they are, are simply not concerned with this question.

Newton’s reply to Leibniz’s criticism was that if “*From the beginning of creation, everything has happened without any regulation or intervention by God*” then this would strengthen the hands of deistic or atheistic sceptics.<sup>18</sup>

So does the argument that God mainly sustains the physical world in a regular way lead to deism? It is true that if we could find an unambiguous miracle in natural history, then this would weaken the case for deism. But on the other hand, it can be argued that in Newton’s phrase “intervention by God” we can spot the seeds — underlying assumptions of a quasi-independent nature in which God occasionally intervenes<sup>19</sup> — that helped deism flourish in the centuries that followed him.

The Bible doesn’t leave any room for such deistic assumptions.<sup>20</sup> Although it is silent on the exact mechanisms by which God acts in the world (as fascinating and important as this question is<sup>21</sup>) it is loud and clear in its proclamation that God’s providence extends to all of creation. He is sovereign over the whole caboodle. We are called to trust in a God who cares for the sparrows and numbers the hairs on our head. We are warned against the ancient heresy of worshiping a magical and capricious creation, and also against the modern heresy of deism, be it metaphysical or practical, when even Christians live as if God won’t act in their lives:

*Therefore I tell you, do not worry about your life, what you will eat or drink; or about your body, what you will wear. Is not life more important than food, and the body more important than clothes? Look at the birds of the air; they do not sow or reap or store away in barns, and yet your*

*heavenly Father feeds them. Are you not much more valuable than they? Who of you by worrying can add a single hour to his life?*

*And why do you worry about clothes? See how the lilies of the field grow. They do not labor or spin. Yet I tell you that not even Solomon in all his splendor was dressed like one of these. If that is how God clothes the grass of the field, which is here today and tomorrow is thrown into the fire, will he not much more clothe you, O you of little faith? So do not worry, saying, 'What shall we eat?' or 'What shall we drink?' or 'What shall we wear?' For the pagans run after all these things, and your heavenly Father knows that you need them. But seek first his kingdom and his righteousness, and all these things will be given to you as well.*

- Matthew 6:25-33

## SCIENCE AND NATURAL THEOLOGY

*The heavens declare the glory of God;  
the skies proclaim the work of his hands.*

- Psalm 19:1

*For since the creation of the world God's invisible qualities -- his eternal power and divine nature -- have been clearly seen, being understood from what has been made, so that men are without excuse.*

- Romans 1:20

*I wonder at the hardihood with which such persons undertake to talk about God. In a treatise addressed to infidels they begin with a chapter proving the existence of God from the works of Nature . . . this only gives their readers grounds for thinking that the proofs of our religion are very weak. . . . It is a remarkable fact that no canonical writer has ever used Nature to prove God.*

- Blaise Pascal, *Pensées*, iv, 242, 243

The Bible repeatedly proclaims that the whole of the cosmos declares the glory of God. It even goes so far as to say that men are without excuse because God's eternal power and divine nature can be understood from what has been made (Rom 1). This must surely mean that, however vaguely, people can perceive attributes of God by their own observations of nature. Extracting such knowledge about God from nature is called "Natural Theology".<sup>22</sup>

Since these passages of inspired Scripture apply to people of all cultures over all of human history, it must be the case that, in the words of James Barr:

*It is easily available public knowledge [that is seen] by everyone...not...information that is not otherwise known: it is rather...of new insight into matter that is already "naturally" known and familiar"<sup>23</sup>*

It is therefore unclear how modern science fits into this picture. Nevertheless, given that science allows us to understand so much more about nature, should we not be able to use these advances to learn more about God? It has certainly been tempting to think along these lines, especially as science increasingly acquired cultural prestige. Attempts at such a natural theology reached their apogee with William Paley's *Natural Theology; or, Evidences of the Existence and Attributes of the Deity* (1802), and the subsequent Bridgewater Treatises written to demonstrate the "power, wisdom, and goodness of God as manifested in the creation." My favorite title is: *Chemistry, Meteorology, and the Function of Digestion: Considered with Reference to Natural Theology* (1834), written by William Prout (1785–1850). Finding God in digestion? Really.

It should be noted that even during the nineteenth century heyday of natural theology, there was considerable Christian pushback. The more evangelical wing of the church worried that these arguments didn't put enough emphasis on the Bible or the saving work of Christ. More famously, Cardinal Henry Newman, perhaps the most important British theologian of the nineteenth century, was deeply unimpressed, arguing that natural theology would lead to atheism.<sup>24</sup> Later, Karl Barth, perhaps the most influential Protestant theologian of the twentieth century, famously rejected natural theology with an emphatic "Nein!"<sup>25</sup>

*I believe in Jesus Christ, God's Son our Lord, in order to perceive and to understand that God Almighty, the Father, is Creator of heaven and earth. If I did not believe the former, I could not perceive and understand the latter.*<sup>26</sup>

These great theologians were unhappy with the accommodation of natural theology to the rationalistic presuppositions of the Enlightenment and its independence from revelation and the centrality of Christ. They didn't think this approach could lead to reliable theological knowledge.

In spite of this sustained critique by many theological heavyweights (which continues today), modern versions of Paleyesque natural theology remain surprisingly popular in Christian apologetics.<sup>27</sup> In part this is a reaction to an equally a-historical anti-Christian apologetic that makes use of a similar type of natural theology to argue that God does not exist (Richard Dawkins would be the best known exponent). Both sides are beholden to the same rationalistic evidentialism that Newman, Barth and others (e.g. Plantinga and other exponents of Reformed epistemology) so emphatically reject. Until they understand their shared underlying presuppositions, both sides will continue to be locked into a destructive symbiotic embrace.

The attraction of a Paleyesque natural theology may have other roots as well. As Mark Noll points out in his essay, *Evangelicals, Creation, and Scripture: An Overview*, written for last year's BioLogos meeting, another popular assumption, widely shared by many Christians and their atheist interlocutors, is univocity:

*once something is explained clearly and completely as a natural occurrence, there is no other realm of being that can allow it to be described in any other way.*

This leads to well-known fallacies such as conflating mechanism and meaning:

*Why is the kettle boiling?* Because a heat source transfers thermal energy across the container wall into the fluid, increasing the mean-square velocity of the molecules,  $\langle v^2 \rangle$ , which is proportional to the

temperature T. When T reaches 100 degrees C, there is a collective phase transition from a condensed liquid state to an expanded gaseous state. We call this process boiling.

*Why is the kettle boiling?* Because I fancy a cup of tea, would you like one?

The mechanistic explanation does not exhaust all layers of meaning. Explaining something scientifically does not explain it away. Nevertheless the conflation of mechanism and meaning and related fallacies such as “nothing buttery” (i.e. if we are made of chemicals, is love “nothing but” a (bio)chemical reaction?) are extremely common in public discourse on the meaning of scientific discoveries.<sup>28</sup>

Another widely shared fallacy, fed by univocity and Paleyesque natural theology, is that “*where we come from determines who we are and how we should then live*”. This fallacy is exploited by the new atheists, and also lies at the origin of a great deal of the Christian resistance to the concepts like common ancestry. Of course Christians should recognize that answers to the questions of human identity and purpose come not from nature, but from Scripture. But until the grip of nineteenth century-style natural theology is weakened, discussions about biological evolution will be hard.

## Natural Theology and Evolutionary Metaphors

*Pure chance, absolutely free but blind, is at the very root of the stupendous edifice of evolution .... The ancient covenant is in pieces; man at last knows that he is alone in the unfeeling immensity of the universe, out of which he only emerged by chance.*

- Jacques Monod,

*Chance and Necessity: An Essay on the Natural Philosophy of Modern Biology*, Knopf (1972)

*There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved.*

- Charles Darwin, *Origin of Species* (1859)

The main message of the previous section is that Christians need to be very careful when trying to derive theological truths from the mechanisms of nature. But it is not all doom and gloom for natural theology. Alister McGrath, for example, has recently called for a renewed approach that is more sensitive to the critiques of Newman, Barth, and others:

*Contrary to the Enlightenment’s aspirations for a universal natural theology, based on common human reason and experience of nature, we hold that a Christian natural theology is grounded in and informed by a characteristic Christian theological foundation. A Christian understanding of nature is the intellectual prerequisite for a natural theology which discloses the Christian God.*<sup>29</sup>



There is no “view from nowhere”. So if we start from Christian presuppositions, does this make more sense of the world than other vantage points do? Does what we observe within the natural order resonate with the core themes of the Christian vision of God?<sup>30</sup> This approach is potentially much more fruitful, and McGrath makes a very impressive start with his recent Gifford lectures<sup>31</sup>, which include a gentle attempt to look at biological evolution, and explore a fascinating connection to Augustinian notions of primordial actuality and emergent possibility.

Nevertheless, we probably don’t understand enough about biology to make much progress towards a detailed natural theology. That doesn’t mean that many Christians and Naturalists haven’t tried. Most popular attempts tend to flounder into some version of either *God of the gaps* or *atheism of the gaps*. One of the biggest problems is the reliance on metaphors that anthropomorphize natural processes (including evolution), and/or introduce all kinds of morally-freighted terminology.

And before we can even speak of metaphors, it is necessary to delineate what we mean by evolution. As many authors have pointed out, the word evolution has many meanings.<sup>32</sup> Here is a simple taxonomy:

- 1) **Evolution as natural history:** The earth is old and the kinds of organisms that populate our world have changed over time.
- 2) **Evolution as a mechanism:** A combination of variation and natural selection helps explain the structure of the observed change over time in natural history .<sup>33</sup>
- 3) **Evolution as a worldview:** Evolution as a way of seeing the world and extracting meaning from it. See e.g. George Gaylord Simpson’s famous quote: *Man is the result of a purposeless and materialistic process that did not have him in mind. He was not planned. He is a state of matter, a form of life, a sort of animal, and a species of the Order Primates, akin nearly or remotely to all of life and indeed to all that is material.*<sup>34</sup>

Christians rightly reject definition 3. Almost all the hermeneutical tension with Scripture arises from natural history (what about Adam, the fall, etc.). But as critically important as these theological issues are, I won’t treat that topic here.<sup>35</sup> Nevertheless, much Christian resistance to evolution also arises from definition 2. That is the main sense in which I will be using the word when examining the following metaphors:

### Random or Stochastic?

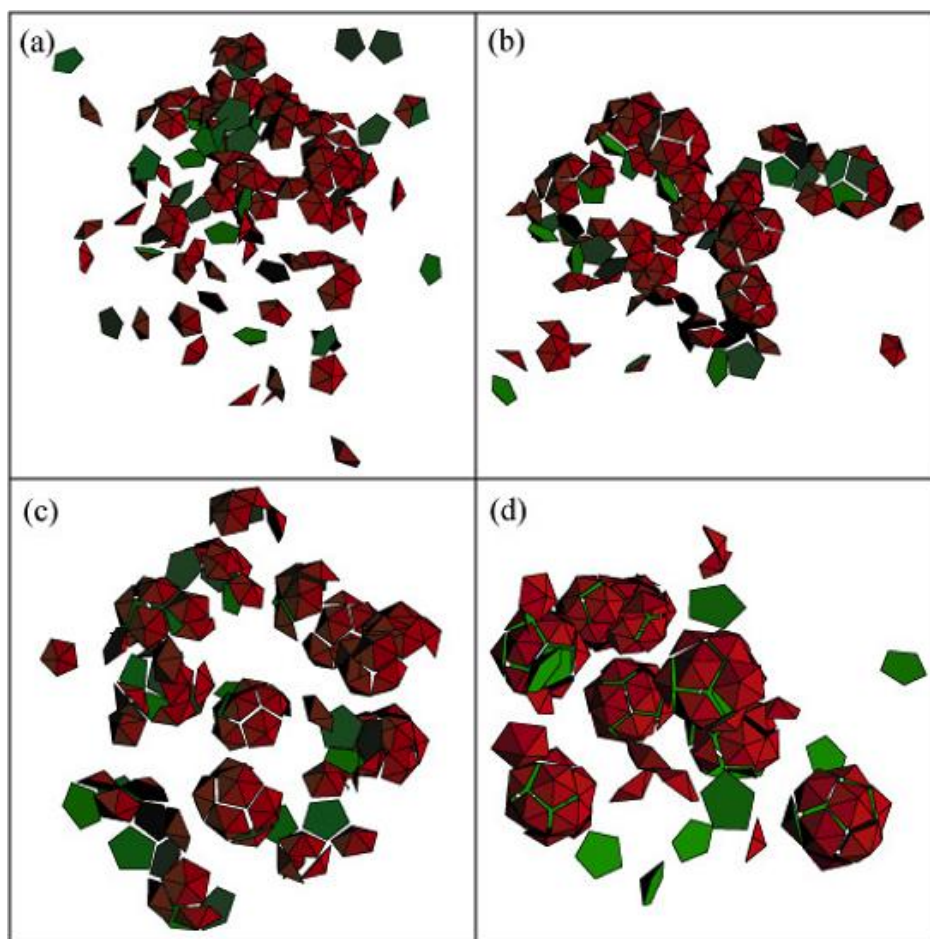
Monte Carlo algorithms that rely on random sampling are routinely used to calculate everything from the value of your stock portfolio to the airflow around a rocket returning into the atmosphere. They are part of a wider class of so-called stochastic methods. It is not hard to demonstrate that for many high-dimensional problems such stochastic methods are the most efficient solution methods available. If you view evolution as an optimization problem in a very high dimensional space<sup>36</sup>, then the most efficient way to solve this problem would probably be by stochastic methods. From that perspective it is not surprising that, if God wanted a universe where biological complexity emerged through the regular ways he sustains the universe, he would employ a stochastic algorithm to achieve this goal. The problem is that the word “random variation” has all kinds of other value-laden connotations. If instead we used the technical term “stochastic variation” it could clear up a lot of confusion.

In this context it is important to emphasize that although Monte-Carlo algorithms employ stochastic methods to generate variation, they are not random in their outcomes. They converge on the desired

solution only if you chose the right kinds of variation and the right kind of selection. One could, in fact, aptly employ the metaphor “survival of the fittest” to describe the way a Monte Carlo program selects between the stochastically generated variations to solve a problem, say, in engineering, but hopefully the temptation to extract further meaning from this metaphor would be curtailed.

### Self-assembly – shaking a box of Legos and out comes a fully formed train?

Your body is full of intricate machinery. If you were to happen across a scaled up version of one of these machines, you’d assume that it was made by an assembly line or some other much more complex system. But in biology there are no such factories. Instead composite objects self-assemble – they make themselves. It is a little bit like having special Lego blocks. You put them in a box, shake it, and out comes a fully formed train. I’m sure most people would agree that such Lego bricks would be much more impressive than the standard ones. This self-assembly metaphor nicely captures what happens in evolution. Rather than making things fully formed, God could have used a process by which things “make themselves”.<sup>37</sup>



From my lab: a picture of the self-assembly of a model T=1 icosahedral virus. Time increases from (a) → (d). Each virus capsid is made up of 12 pentagonal bipyramids. If the interactions between the particles are designed correctly, they can be placed at random initial positions, and then move around randomly, but they nevertheless will always end up as well-formed icosahedra. The correct design depends more on the topology of the search space than it relies on the types of random (stochastic) steps available. See I. G. Johnston, A. A. Louis and J. P.K. Doye, “Modelling the Self-Assembly of Virus Capsids”, *J. Phys.: Condensed Matter*, **22**, 104101 (2010) for more details.

### Genes as blueprints or as networks of switches?

One of the surprises that came out of the human genome project was how few genes (protein coding stretches of DNA) humans have — around 23,000, not that different compared to the fruit fly with 14,000, and quite a bit less than rice, with 51,000.<sup>38</sup> Traditionally the metaphor for genes was something more akin to a blueprint, — the “standard dogma” of Francis Crick: each gene codes for one mRNA which codes for one protein — but now we realize that many are better viewed as switches or volume knobs. Moreover, one gene can have multiple effects. Complexity arises not so much from the genes themselves as from the connections between them. These network properties are currently an enormously rich topic of research. For example, the way the network is connected can dramatically affect the interplay between robustness to mutation and evolvability (the ability of a system to generate heritable phenotypic novelty).<sup>39</sup> The single gene <—> single property blueprint metaphor is outdated.

### Shaven baby, tinman, pax-6 and sonic-hedgehog.

Genes that behave like switches have important consequences for development (how an organism changes from a fertilized cell into an adult). They are often given whimsical names like *shaven baby* (which makes the embryo hair fall off) or *tinman* (which governs development of the heart; the name comes from *The Wonderful Wizard of Oz*) or *sonic hedgehog* (a mutation in this genes gives the embryo little spikes). The same gene often turns out to be used throughout the animal kingdom: you can take the *pax-6* gene that controls eye development from a human and put it into the part of a fly that controls wings formation and the fly will make a (malformed) eye on its wing. The same gene that controls the formation of human arms also controls the formation of wings on birds, fins on fish, and legs on centipedes! Modifying the way these genes are “wired together” can lead to massive changes in an organism. The burgeoning new field of *evo-devo* (evolutionary developmental biology) studies how evolution exploits these “toolbox genes” to help generate the *endless forms most beautiful* we see around us. Much remains to be understood, but adjectives like remarkable, elegant, and awe-inspiring are apt.<sup>40</sup>

### Clay or Lego blocks?

In a fascinating book proposing a “theory of facilitated variation”<sup>41</sup>, biologists Marc Kirschner and John Gehrard point out that while the Modern Synthesis<sup>42</sup> implicitly used the metaphor of clay -- evolution could produce variation in almost any direction, but in very tiny steps -- modern biology would be better served by the metaphor of Lego blocks: reusable connectable units are more constrained in what they can do, but you can generate useful new variation in much larger steps.

### Selfish genes, or control on many levels?

The field of systems biology is challenging the reductionist bottom-up primacy that has dominated biological explanation over the last few decades. In a beautiful book, *The Music of Life: Biology beyond the Genome* (OUP 2006), Denis Noble, a remarkable polymath and one of the fathers of systems biology, takes the gene-centric view of his Oxford colleague Richard Dawkins to task. He asserts that we must look beyond the “selfish gene”. A better metaphor for understanding life is music, “*a symphonic interplay between genes, cells, organs, body, and environment*”. Earlier on in the book he mischievously inverts a famous passage from Dawkins’ *The Selfish Gene* (OUP 2006) (see next page).



[Genes] swarm in huge colonies, safe inside gigantic lumbering robots, sealed off from the outside world, communicating with it by tortuous indirect routes, manipulating it by remote control. They are in you and me; they created us, body and mind; and **their preservation is the ultimate rationale for our existence.**

Richard Dawkins --  
*The Selfish Gene* (1976)

v.s.

[Genes] are trapped in huge colonies, locked inside highly intelligent beings, moulded by the outside world, communicating with it by complex processes, through which, blindly, as if by magic, function emerges. They are in you and me; we are the system that allows their code to be read; and their preservation is totally dependent on the joy that we experience in reproducing ourselves. **We are the ultimate rationale for their existence.**

Denis Noble --  
*The Music of Life: Biology Beyond the Genome* (OUP 2006)

Dawkins himself admits that there is no experiment that he knows of that could distinguish these two viewpoints.<sup>43</sup> Nevertheless, this example does illustrate the power of metaphors: the concept of a “selfish gene” now permeates much popular thinking about evolutionary biology. There is a technical sense in which it is useful (e.g. in arguments about levels of selection<sup>44</sup>), but as a morally-freighted metaphor it is seriously misleading.<sup>45, 46</sup>

### Evolution as a tinkerer, or as an engineer?

In a famous 1977 article entitled “*Evolution as a Tinkerer*”<sup>47</sup>, the French Nobel prize winner Francois Jacob<sup>48</sup> introduced a powerful metaphor for the way that evolution can, for example, co-opt existing processes towards new ends. Unfortunately this metaphor also carries overtones such as ad-hoc and sub-standard. These connotations are then reflected in public debates about evolution. Whether tinkering is the best vantage point from which to view evolution is also not at all clear. In a provocative paper entitled “*Biological Networks: The Tinkerer as an Engineer*”<sup>49</sup>, the systems biologist Uri Alon showed how the biochemical networks that control cells display good engineering principles such as modularity, robustness, and the re-use of components. It should be kept in mind that the question of optimality is highly contested in evolutionary biology. To properly assess such questions one often needs consider counterfactuals, something that is much harder to do in biology than it is in say physics.<sup>50</sup> Nevertheless, it seems to me that Jacob’s “tinkerer” metaphor is not nearly as widely applicable as some biologists claim.

### Contingency or inevitable outcomes?

*Wind back the tape of life to the early days of the Burgess Shale; let it play again from an identical starting point, and the chance becomes vanishingly small that anything like human intelligence would grace the replay.” In evolution, there is no direction, no progression. Humanity is dethroned from its exalted view of its own importance.*

- Stephen J. Gould, *Wonderful Life* (W.W. Norton 1989)



*When you examine the tapestry of evolution you see the same patterns emerging over and over again. Gould's idea of rerunning the tape of life is not hypothetical; it's happening all around us. And the result is well known to biologists — evolutionary convergence. When convergence is the rule, you can rerun the tape of life as often as you like and the outcome will be much the same. Convergence means that life is not only predictable at a basic level; it also has a direction. .... the constraints of evolution and the ubiquity of convergence make the emergence of something like ourselves a near-inevitability.*

- Simon Conway Morris, *Life's Solution: Inevitable Humans in a Lonely Universe* (CUP, 2003)

These two quotes could not be more different. Regardless of the metaphysical implications,<sup>51</sup> it is a very fascinating scientific question to ask which man is right. Gould's view is widely shared among biologists and frequently repeated in public debate. However, Conway Morris, one of the heroes of *Wonderful Life*, lists an astonishing catalogue of examples of convergence -- from antifreeze proteins to echolocation to social organization<sup>52,53</sup> -- where the same features emerge independently in evolution. This paper is not the right forum to discuss the scientific implications of all this convergence.<sup>54</sup> What is clear, I hope, is that evolution appears to be much more constrained than earlier generations may have thought.

### **So what shall we make of all these metaphors?**

One could describe evolution as a blind, purposeless, and directionless process that tinkers by modifying the genetic blueprints that determine our infinitely malleable biological outcomes. By a combination of random chance and survival of the fittest it stumbles upon contingent organisms best described as secondary phenomena cobbled together by selfish genes.<sup>55</sup>

Or one could instead describe evolution as “*a symphonic interplay between genes, cells, organs, body, and environment*” that wires a toolkit of Lego-like components into interacting networks in order to explore a highly structured search space. The (inevitable?) outcome of this stochastic process is the emergent self-assembly of the “*endless forms most beautiful*” that include you and I.

The fact that there are so many different metaphors reflects the many facets of evolutionary processes. Christians may find some of these metaphors more palatable than others.<sup>56</sup> But it must be kept in mind that all these metaphors, even those with which Christians would be more comfortable, are limited in their ability to fully capture the detailed scientific mechanisms at work. Nevertheless, familiarity with a broader spectrum of metaphors can help a Christian recognize the rhetorical subterfuge of those who pick specific metaphors over others in order to advance ideological agendas.<sup>56</sup> The most important point of this section is, however, that all these metaphors are severely restricted in what they can tell us about *where we come from and how we should then live*.

## **SCIENCE, SCIENTISTS AND THE CHURCH**

*[Science is a Tapestry]. An enormous multiplicity of strands of evidence, many of them weak and ambiguous, can make a coherent logical bond whose strength is enormous.*

-- David Mermin”, “What's Wrong with this Sustaining Myth?” *Physics Today* **49**, 11 (1996)

*When you are a Bear of Very Little Brain, and you Think of Things, you find sometimes that a Thing which seemed very Thingish inside you is quite different when it gets out into the open and has other people looking at it.*

-- A. A. Milne, *The House at Pooh Corner* (Methuen & Co. Ltd. 1928)

When I was a child growing up in central Africa, I didn't come across too many PhDs. I assumed that someone with Dr. in front of their name would surely know nearly all there is to know about their subject and a great deal more about the rest of the world of academic thought. I've now got one myself and supervised and examined a good number of PhD theses in both physics and chemistry. It has certainly disabused me of the idea that I or for that matter most people with PhDs know a great deal about anything beyond the very narrow confines of our (sub)specialties.

How does the scientific enterprise progress then? For that I turn to one of my favorite science writers, the physicist David Mermin, who used the metaphor of science as a tapestry made up of many threads. In a previous essay I wrote that rather than being an individual endeavor:

*Creating scientific tapestries is a collective endeavor building on mutual trust and the communal experience of what kinds of arguments and evidence are likely to stand the test of time. In part because the skill of weaving reliable scientific tapestries relies on subtle judgments, a young scientist may work for years as an apprentice of older and more experienced practitioners before branching out on his own. In this process there are many parallels with the guilds of old. I am fond of this metaphor because it describes what I think I experience from the inside as a scientist. Moreover, it also emphasizes the importance of coherence and consistency when I weave together arguments and data to make an "inference to a best explanation".<sup>57</sup>*

Peter Harrison has advanced an intriguing argument that modern experimental science has its roots in the Protestant Reformation:

*An implication of Calvinist theological anthropology, I believe, was that we have to augment our natural faculties with instruments like telescopes and microscopes, and manipulate the natural world experimentally because it's inherently deceitful. We need to do all these things to guard against the easy assumption that our faculties give us a reliable account of the natural world.<sup>58</sup>*

This recognition of the noetic effects of sin also underlies the development of collective processes of error correction in modern science: "*Sometimes ... a Thing which seemed very Thingish inside you is quite different when it gets out into the open and has other people looking at it.*"

One consequence of this collective method of knowledge generation is that it can be difficult for an outsider to assess the strengths and weaknesses of an argument in a specific field. Moreover, the way one weaves tapestries can vary from field to field. Although the reasons for these differences are often unwritten (leading to frustration in interdisciplinary work) they don't arise so much from cultural or sociological factors (although these do play a role) but rather are mainly determined by the kinds of questions that one is trying to address.

For example, some scientific concepts are built on a small number of observations that make very strong individual threads in a tapestry argument. Others are built on a much larger number of observations that may each be much weaker, but when woven together, “*make a coherent logical bond whose strength is enormous*”.

A good example of the latter would be the arguments that geologists employ for an earth that is about 4.5 billions of years old. Although one might pick at many of the individual threads (as young earth advocates are apt to do), it is the sheer number of strands combined with the intricate structure of the whole interconnected tapestry that leads to the overwhelming scientific consensus on this issue. The full rationale for such assessments is sometimes hard for scientists to clearly communicate, and, by the same token, hard for laypeople to properly evaluate.

On the other hand, Christian laypeople should not take all of the confident pronouncements that emanate from our citadels of learning without a grain of salt. Sometimes the phrase “it has been scientifically proven” is shorthand for “shut up and believe me”.

So a big question for the church is: who can you trust to assess the implications of new scientific discoveries?<sup>59</sup> The answer is certainly not individuals, no matter how gifted. The process of discernment must draw on communities of collective expertise. As Mark Noll and others have pointed out, this is unfortunately not an area where the evangelical church has invested sufficient time or resources.

One place the church could look is to the many Christian academics who do research in the natural sciences. There are many more of these around than laypeople may realize. Here in Oxford I can count at least 10 professors of physics who are active in their local churches.<sup>60</sup> However, there are several barriers to overcome. Firstly the insane busyness of the academic profession, with its multiple conflicting demands of administration, teaching and research, makes it very hard for Christian academics to be responsible parents/husbands/wives, good church citizens, and also find the time to engage significantly with the wider Christian public. Secondly, the profession as a whole still looks down its nose at popularisers, and Christian academics are not immune to this. Thirdly, for a multitude of reasons<sup>61</sup> many Christian academics have had difficult experiences when engaging on intellectual issues with the church and vice versa. Some diplomacy may be needed before they are willing to re-engage.<sup>62</sup>

## CONCLUSION

In conclusion then, I think the barriers to the church properly discerning the strengths and weaknesses of the BioLogos model do not lie primarily in the content of its science or even in the worry that this approach may lead to deism. These are challenges to be sure. Evangelicals’ concerns about deism, for example, often have their primary origin in a sub-Biblical understanding of how God sustains the world and a rationalistic approach to natural theology that has been strongly influenced by the Enlightenment. Both these unexamined notions are shared by the general public. To make progress here, it is important for the BioLogos team to sensitively confront the ways we in the church have all been shaped by the spirit of the age. That means listening as well as talking. Moreover, those of us who work in the sciences need to learn how to better communicate the essence of our professional work to the rest of the body of Christ. Among other things, that means a careful assessment of the metaphors we inevitably need to use.

But these are not insurmountable challenges. A much more formidable barrier revolves around the issue of trust. How can the church discern the truth on such complex issues? How can it respond to the Newtons and Leibnizes of today? Where are the trusted communities of specialists to help it negotiate the

tapestries of scientific arguments, while simultaneously carefully engaging with the philosophical and theological questions this may raise? Perhaps BioLogos can become part of that crucial “missing link”. But to do that it must be deeply embedded in the wider body, picking its battles carefully and strategically, and building alliances wherever possible. For this, as in everything, we need the guidance of the Holy Spirit: “Unless the Lord builds the house, the laborers labor in vain” (Psalm 127:1).

## Notes

1. John Hedley Brooke, *Science and Religion*, CUP, Cambridge (1991), p147
2. From letter 1 point 4 (Nov 1715). The full correspondence can be found online at <http://www.earlymoderntexts.com/leibclar.html>. As always in history, the whole story is more complex (and interesting) than the bits I highlight here.
3. For another example: “Because there is a law such as gravity, the universe can and will create itself from [the structured vacuum of modern physics]. Spontaneous creation is the reason there is something rather than nothing, why the universe exists, why we exist” - *The Grand Design*, Stephen Hawking and Leonard Mlodinow, Bantam (2010)
4. Alister E. McGrath, *The Open Secret: A New Vision for Natural Theology*, Wiley-Blackwell, (2008)
5. William Paley, *Natural Theology; or, Evidences of the Existence and Attributes of the Deity* (1802)
6. Richard Dawkins, *The Blind Watchmaker*, Norton (1986)
7. Mark Noll, “The Evangelical Mind Today.” *First Things* (October 2004)
8. See e.g. David Wilkingson, *The Message of Creation*, IVP, Leicester (2002)
9. Clues like: “How can it be morning and evening without a sun and moon?” led many early church fathers to reject simple chronological or “journalistic” interpretations of Genesis. See e.g. Origen (185-254) *First Principles*, 4.3 or Augustine of Hippo (354-430) who wrote “On this subject there are three main views. According to the first, some wish to understand paradise only in a material way. According to the second, others wish to take it only in a spiritual way. According to the third, others understand it both ways, taking some things materially and others spiritually. If I may briefly mention my own opinion, I prefer the third”, *De Gen. ad litt VIII*, 1 p. For a longer discussion of these points, see E. Lucas, *Can we Believe Genesis Today*, IVP, Leicester, (2001)
10. The term God of the gaps probably originated with Henry Drummond. Dietrich Bonhoeffer also warned against it, as did Charles Coulson, the first professor of theoretical chemistry at Oxford University: “This [God of the gaps] is a fatal step to take. For it is to assert that you can plant some sort of hedge in the country of the mind to mark the boundary where a transfer of authority takes place. ... Either God is in the whole of Nature, with no gaps, or He’s not there at all.” - Charles Coulson, *Christianity in an Age of Science*, 25<sup>th</sup> Riddell Memorial Lecture Series, OUP, (1953)
11. “Moses wrote in a popular style things which, without instruction, all ordinary persons, endued with common sense, are able to understand”, John Calvin, commenting on Gen 1:16 in *Institutes of the Christian Religion* (1559)
12. See e.g. R. Hooykaas, *Religion and the Rise of Modern Science*, Eerdmans, Grand Rapids (1972); R. Numbers, *Galileo Went to Jail and 25 Other Myths about Science and Religion*, HUP, (2009); P. Harrison, *The Bible and the Rise of Modern Science*, CUP (1998)
13. John Donne, *Eighty Sermons*, #22 (1640)
14. Even though they could not be further apart metaphysically, this robust theistic framework and an ontological naturalism would both suggest that methodological naturalism is the best way to study the natural world. Of course their ultimate justifications for this conclusion are completely different, and theists would probably prefer a term other than “methodological naturalism”. It is, in fact, interesting to speculate how one would derive (rather than assume) the underlying metaphysical principles that undergird science from a starting point of pure naturalism. Given the deep and often unrecognized theological roots of modern science, it may be hard for naturalists not to inadvertently smuggle these concepts into the arguments.
15. I have written in more detail about miracles and science elsewhere. See [The BioLogos site](#) for a translation of A.A. Louis, *Wonderen en wetenschap: De lange schaduw van David Hume*, in Cees Dekker, Rene’ van Woudenberg en Gijsbert van den Brink, eds., *Omhoog kijken in Platland*, Ten Have (2007)
16. Of course this doesn’t mean that science has nothing to say about miracles. If, for example, someone claims to be healed by God, the methods of modern science could be used to see if their illness is really gone. The often-heard claim that modern science has made the miracles of the Bible less likely is a category mistake that has more to do with worldview assumptions that originate outside of science than with science itself. Another kind of category mistake occurs, for example, in the design of double blind studies of whether prayer works for hospital patients who don’t know they are being prayed for. If



there is no God it obviously won't work. But the same is likely to hold if there is a God. It would seem very improbable that we could control when he appears to sustain the world by regular or less regular ways.

17. I am not aware of a good theological rationale for using methods derived from science to detect miracles in natural history. Of course this doesn't mean that it can't be done in principle, but Christians should think hard before making any such claims. Although they may balk at this language, I believe that Christian Intelligent Design advocates need to develop a clearer theological justification for their program.
18. From the first reply (26 November 1715, point 4). Newton seems to suggest two options -- Nature is semi-independent, or completely independent. <http://www.earlymoderntexts.com/leibclar.html>
19. "You may have noticed I never say God intervenes in the world; I always say God interacts with the world. Interaction is a continuous, consistent word; intervention is a fitful, episodic sort of word. It is inconceivable theologically that God acts as a celestial conjurer, doing a turn today to impress people that he won't bother to do tomorrow. God must be utterly consistent in his relationship with the world, but consistency does not mean a dreary uniformity. So the problem of miracle is to understand how it fits in with the rest of God's action. If you like, the problem of miracle is not 'do they happen?' but 'why don't they happen more frequently?'" - John Polkinghorne, <http://www.polkinghorne.net/action.html>
20. Oliver R. Barclay, "Design in Nature", *Science & Christian Belief*, **18**, 49 (2006)
21. The literature on this topic is rich and subtle. There are multiple proposals that could potentially be consistent with Scripture. Think of the distinction between primary and secondary causes in Thomism (read e.g. William Carroll), Austin Farrer's "double agency", causal windows in quantum mechanics and chaos theory (Polkinghorne) etc. see e.g. Keith Ward *Divine Action*, Templeton (2008) for an accessible overview. Regardless of which one you prefer, it should not detract from the biblical doctrine of a God who providentially cares for this world and for each of our lives, according to his divine purposes. Moreover, the exact nature of God's action may be a topic, like free-will and predestination, for which analogies to the history of quantum mechanics suggest that we should hold onto our differences lightly (see A. A. Louis, *Conflict of boedelscheiding?* in Martine van Veelen and Cees Dekker (ed) *Hete Hangijzers*, Buijten en Schipperheijn, (2009)). See also Amos Yong who writes: "For both scientific ... and religious ... reasons, a plausible theory of divine action still lies beyond our reach", in his helpful review article: A. Yong, "Divine Action in theology and science: a review essay", *Zygon* **43**, (2008), p 198
22. It is also important to note that the biblical writers were not normally concerned with atheism. As Pascal points out, the Bible doesn't use nature to prove the existence of God. This most likely applies to the Rom 1:20 passage as well, which focuses on which qualities of God are discernable, rather than on whether he exists or not.
23. J. Barr, *Biblical Faith and Natural Theology*, Oxford:Clarendon Press (1993), p83
24. [According to] Newman, the God of natural theology "is not very different from the God of the Pantheist ... I really doubt," he ended, "whether I should not prefer that [the natural theologian] should be an Atheist at once than such a naturalistic, pantheistic religionist. His profession of theology deceives others, [and] perhaps deceives himself." This quote from Newman's *The Idea of a University* (1852) comes from Mark A. Kalthoff's fascinating article: "A Different Voice from the Eve of The Origin: Reconsidering John Henry Newman on Christianity, Science, and Intelligent Design", *PSCF* **53** (March 2001)
25. "Nein!" or "No!" was the one-word title of Barth's famous response to Emil Brunner's 1934 treatise on natural theology entitled "Nature and Grace".
26. Citation from K. Barth, *Church Dogmatics vol III, (1948)* p29
27. A lot of young earth creation science (YECS) would fall into this category, but importantly not all of it.
28. These fallacies are all closely related to the problem of "scientism" more extensively discussed in Ian H. Hutchinson's accompanying BioLogos paper "Engaging Today's Militant Atheist Arguments."
29. A.E. McGrath, *The Open Secret: A New Vision for Natural Theology*, Oxford: Blackwell (2008), p4
30. Another important theme emphasized by McGrath is that natural theology should not just be cerebral and cognitive, but should also include aesthetic and other forms of discernment.
31. A.W. McGrath, *A Fine-Tuned Universe: Science, Theology, and the Quest for God* (2009)
32. See e.g. Tim Keller in his essay "[Creation, Evolution, and Christian Laypeople](#)" written for last year's BioLogos meeting.
33. By employing mechanisms of variation and selection, our immune system is able to respond to a vast array of pathogens with only a limited number of protein encoding genes. Christians agree that God created this mechanism, but they disagree that it is sufficient to explain some of the biological change we observe over time.
34. George Gaylord Simpson, *The Meaning of Evolution*, Yale University Press (1967), p. 345
35. See the accompanying BioLogos paper by Denis R. Alexander, "[How does a BioLogos model need to address the theological issues associated with an Adam who was not the sole genetic progenitor of humankind?](#)".
36. The full story is more complex, but this simplified picture is sufficient to illustrate the argument.
37. See e.g. Kathryn Applegate, <http://BioLogos.org/blog/thats-random-a-look-at-viral-self-assembly/>

38. <http://www.nature.com/scitable/topicpage/eukaryotic-genome-complexity-437>
39. S. F. Greenbury, I. G. Johnston, M. A. Smith, J. P. K. Doye and A. A. Louis, [The effect of scale-free topology on the robustness and evolvability of gene regulatory networks](#), *J. Theor. Biol.* **267**, 48 (2010)
40. I recommend Sean B. Carroll, *Endless Forms Most Beautiful: The New Science of Evo Devo*, W.W. Norton (2005) for a wonderful popular introduction.
41. Taken from Marc Kirschner and John Gehrhard, *The Plausibility of Life*, Yale University Press, New Haven (2005)
42. The Modern Synthesis refers to the incorporation of genetics into evolutionary theory, achieved mainly in the 1930s and 1940s.
43. For a more extensive discussion see D. Noble, [Neo-Darwinism and Selfish Genes: Are they of use in physiology?](#), *The Journal of Psychology*, doi:10.1113/jphysiol.2010.20138 (2010)
44. S. Okasha, *Evolution and the levels of Selection*. OUP, Oxford (2006)
45. D. Noble, *op cit*.
46. Another interesting stream of thought emphasizes the importance of cooperation in evolution. Well known scientific proponents include Lynn Margulis and Martin Nowak. Cambridge's Sarah Coakley is exploring the theological implications of this theme further, see e.g. <http://www.st-edmunds.cam.ac.uk/faraday/resources/FAR244%20Coakley%20Lecture.pdf>
47. F. Jacob, *Science* **196**, 1161 (1977)
48. Jacob won the Nobel Prize together with Jacques Monod for discovering the first genetic switch!
49. U. Alon, *Science*, **301**, 1866 (2003)
50. See e.g. S. Conway Morris and A.A. Louis, "Is water an amniotic Eden or a corrosive Hell? Emerging perspectives on the strangest fluid in the Universe" in *Water and Life*, eds. J. D. Barrow, S. Conway Morris, J.L. Finney, C.L. Harper and R.M. Lynden-Bell, CRC Press (2010)
51. Christians with a high view of God's providence would probably be content with either viewpoint. Think of I Kings 22, where in v17 the prophet Micaiah prophesies that king Ahab will be killed in battle. Then in v 34 we read: "But someone drew his bow at random and hit the king of Israel between the sections of his armor," which killed him. In the Bible things that appear random or contingent to us (e.g. unplanned by the archer) are not outside God's providential control. See also D. Bartholomew, *God, Chance and Purpose*, Cambridge University Press (2008). I should also point out the metaphysical and theological implications of convergence are much richer than just a question about the role of chance, see e.g. [http://www.iscast.org/conway\\_morris\\_bio](http://www.iscast.org/conway_morris_bio).
52. Simon Conway Morris is cataloguing examples of convergence at <http://www.mapoflife.org/>.
53. My favorite quote on this topic is by Natalie Angier in "[When Nature Discovers The Same Design Over and Over](#)", *NY Times*, Dec 15 1998: "Nature is like Henny Youngman: She writes great jokes, and then flogs them again and again. Take the spiny anteater of Australia, the pangolin of Africa, and the giant anteater of Latin America (please!). Each of these mammals has a long, sticky, worm-like tongue, no teeth to speak of and scimitar claws. Each has bulging salivary glands, a stomach as rugged as a cement mixer and an absurd, extenuated, hairless snout that looks like a cross between a hot dog and a swizzle stick [...] Despite their many resemblances, the three creatures are unrelated to one another; the spiny anteater, in fact, lays eggs and is a close cousin of the duck-billed platypus. What has yoked them into morphological similitude is a powerful and boundlessly enticing process called evolutionary convergence. By the tenet of convergence, there really is a best approach and an ideal set of tools for grappling with life's most demanding jobs. The spiny anteater, pangolin and giant anteater all subsist on a diet of ants and termites, and myrmecophagy, it turns out, is a taxing, specialized trade. As a result, the predecessors of today's various ant hunters gradually, and quite independently, converged on the body plan most suited to exploit a food resource that violently resists exploitation."
54. In my experience physicists are much more attracted to Conway Morris' point of view than biologists are, in part because of the former's penchant for universal laws. For a fascinating discussion on "laws of biology" compare Evelyn Fox Keller, "A clash of culture", *Nature* **445**, 603 (2007) who writes: "Does biology have laws of its own that are universally applicable? Or are the physical sciences the exclusive domain of those laws? By its very nature, life is both contingent and particular, each organism the product of eons of tinkering, of building on what had accumulated over the course of a particular evolutionary trajectory. To what extent will physicists' focus on biology demand a shift in epistemological goals, even the abandonment of their traditional holy grail of universal 'laws'?" to Uri Alon, "Simplicity in Biology", *Nature* **446**, 497 (2007), who writes, "There seems to be a degree of simplicity in several aspects of these networks, which is intriguing given that cells evolved to survive, and not for scientists to understand. I have emphasized simplicity in biology to encourage the point of view that general principles can be discovered. Without such principles it is difficult to imagine how we might ever make sense of biology on the level of an entire cell, tissue or organism."
55. "The individual organism ... is not fundamental to life, but something that emerges when genes, which at the beginning of evolution were separate, warring entities, gang together in co-operative groups as 'selfish co-operators'. The individual organism is not exactly an illusion. It is too concrete for that. But it is a secondary, derived phenomenon, cobbled together as a consequence

- of the actions of fundamentally separate, even warring agents.”* Richard Dawkins, *Unweaving the Rainbow*, Penguin, London (1998) p 308
56. D.R. Alexander and R. L. Numbers, eds., *Biology and Ideology from Descartes to Dawkins*, University of Chicago Press (2010)
  57. [Louis op cit.](#)
  58. Peter Harrison, <http://www.st-edmunds.cam.ac.uk/cis/harrison/Peter%20Harrison%20-%20discussion.htm>. See also P. Harrison, *The Fall of Man and the Foundations of Science*, CUP (2007)
  59. The answers to this question are also intimately related to more complex issues of the public understanding of science and politics. See for example the “Mapping Controversies on Science for Politics (MACOSPOL)” project by the ever fascinating (and enervating) Bruno Latour: <http://www.macospol.org/>
  60. In my experience, you are much more likely to find active Christians in the sciences than in the arts or the humanities. A friend in the Cambridge Earth Sciences department estimates that around 15% of his colleagues there are active evangelical Christians. Although they will all be able to explain why they believe that the earth is billions of years old, they are not a community of scholars that the church draws on in any organized way.
  61. Issues related to the “Scandal of the Evangelical Mind”, pride, isolation, etc. For more see <http://vimeo.com/19990320> .
  62. Someone should write an essay on common pastoral issues that academics face for BioLogos.