Chapter 4
Reflections on Life: Lessons from Evolutionary Biology, with Insights from Sergius Bulgakov

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> *Let me try to make crystal clear what is established beyond reasonable doubt, and what needs further study, about evolution. Evolution as a process that has always gone on in the history of the earth can be doubted only by those who are ignorant of the evidence or are resistant to evidence, owing to emotional blocks or to plain bigotry. By contrast, the mechanisms that bring evolution about certainly need study and clarification. There are no alternatives to evolution as history that can withstand critical examination. Yet we are constantly learning new and important facts about evolutionary mechanisms. (Dobzhansky 1973)*

Abstract In this paper, I set out to make several points, as follows: (1) that evolution is the unifying theory within biology and that nothing in biology makes sense without it: (2) that evolution is tightly linked to another biological science, ecology, and that failure to accept evolution often leads to a failure to accept ecological principles; and (3) that many serious scholars who choose not to accept evolution do so because of false ideas that they believe acceptance of evolution will convey about our society and our world – that many scholars who refuse to accept evolution do so on principles of philosophy or sociology allegedly underlying the theory of evolution. To address the first two points, I will focus on the biological sciences and the connections between science and ethics and philosophy; in response to the third issue, I will reflect not on evolution as science, but on the correct understanding of scientific vocabulary, of human "nature", and of the difference between theology and teleology. For the final point I will especially revisit the thoughts of the Orthodox scholar Sergius Bulgakov (1877–1944) which may help inform some concerns of the critics of evolution.

Keywords Bulgakov • Causality • Determinism • Ecology • Evolution

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Evolution as the Unifying Theory of Biology

Biological evolution is defined as descent with modification. This definition includes both small-scale evolution (such as changes in the frequency of a particular gene within a population from one generation to the next) and large-scale evolution (such as the descent of different species from a common ancestor over many generations). Evolution as a biological theory was first proposed by Charles Darwin, a British naturalist who explained that species develop over time and that they developed from a common origin. His two most important works are *On the Origin of the Species* (Darwin 1859) and then *The Descent of Man, and Selection in Relation to Sex* (Darwin 1871). The major tenets proposed by Darwin and accepted by the mainstream scientific community to this day were that there is a common ancestry for all of life on earth; that species develop through variations in form (now known to be result of inheritable mutations); and that natural selection selects variations and drives speciation. At the time, the books were controversial both from a public view and from a religious perspective. The Church of England's establishment reacted against the book at the time, although this view softened into an uneasy acceptance over the ensuing decades. Even the Roman Catholic Church eventually took a pro-evolution perspective through the work of such noted scholars as Teilhard de Chardin and others.

Evolution was originally presented as a scientific theory: a logically self-consistent model describing the behavior of a natural phenomenon originating and supported by observable facts. Like all other scientific theories (such as the theory of gravity, the theory of relativity, etc.), evolutionary theory is formulated, developed, and evaluated according to the scientific method. Often in everyday language, people equate the word "theory" with a "speculation" or a "conjecture." In scientific practice, however, the word theory has a very specific meaning – it is a model of the world (or some portion of it) from which falsifiable hypotheses can be generated and verified (or not) through empirical observation of facts. In this way, the concepts of "theory" and "fact" are not opposed to each other but rather exist in a reciprocal relationship. While it is a fact that an apple falls from a tree, it is the theory of gravity that explains it. The scientific method which is used to test a scientific theory is not radically different from a rational attitude that is used in many aspects of everyday life (Peacocke 2001: 26). The scientific method is characterized by several major features: (1) it uses an objectivity in approach where the goal is to observe events as they are without falsifying them: (2) the results (if produced experimentally) must be reproducible in a broad sense in laboratories anywhere in the world: (3) there is an interplay of inductive reasoning (from specific observation and experiments) and deductive reasoning (reasoning from theories to account for specific experimental results); and (4) the objective of the work is to develop broad laws that become part of humanity's understanding of nature (such as the theory of gravity developed by Isaac Newton). The definition of a scientific theory, which is generally considered to be a paradigm that is proven or assumed to be true, is in marked contrast to a dogma, which is a principle that is proclaimed as true. It is essential to science to fight hard to be open to any changes imposed on it by the utilization of the scientific method.

For that reason, the vocabulary of science is cautious: science has refrained from making dogmatic claims; instead, it relies upon hypotheses, which are assumptions used as the basis for investigation or argument, and which can be tested. Proven hypotheses support and modulate their originating theory.

The textbook definition of evolution describes it in a broad sense as a process of change, but biological evolution itself is much more limited in definition. Futuyma (1997) in his book *Evolutionary Biology* makes the following distinction:

> In the broadest sense, evolution is merely change, and so is all-pervasive; galaxies, languages, and political systems all evolve. Biological evolution [. . .] is change in the properties of populations of organisms that transcend the lifetime of a single individual. The ontogeny of an individual is not considered evolution; individual organisms do not evolve. The changes in populations that are considered evolutionary are those that are inheritable via the genetic material from one generation to the next. Biological evolution may be slight or substantial; it embraces everything from slight changes in the proportion of different alleles within a population (such as those determining blood types) to the successive alteration that led from the earliest protoorganism to snails, bees, giraffes, and dandelions. (Futuyma 1997: 751)

Biological evolution, then, does not act upon individuals but rather on populations (Smith and Szathmáry 1999: 81; Wilson 2002: 9). The fate of individuals can be affected by their traits, but individuals do not undergo biological evolution: changes we undergo in life may perhaps be called “personal evolution”, but not biological evolution. A natural unit enacting biological evolution is the population. A population acts essentially as a collection of genes and genotypes that evolves, and the evolution of the population can be expressed as a change in the frequency of certain genes and genotypes in the population. For example, the prevalence of lighter skinned individuals in dusky climates and darker skinned individuals in sunny climates resulted from a selection of gene combinations balancing D vitamin deficiency and protection against UV light-induced mutations; since neither of these issues is instantly lethal, and they are mutually opposed to each other, selection pressure over many generations lead to the skin color gradient between equatorial Africa and Sweden. It is not the purpose of this work to provide a proof for biological evolution. Despite alleged challenges (Behe 1998) there is an overwhelming body of support for biological evolution in the scientific literature that comes from protein and DNA data, from the fossil and geological records, physiological and functional studies, and much more (see for example, any textbook of biology currently used in universities today).

Biological evolution (throughout the remainder of this text referred to as evolution) is the unifying theory of biology. Results of evolution shape the lives of people in almost every respect of everyday life. Agriculture and medicine have used the principles of evolution for centuries before that word was ever used for the first time. Regardless of their attitude toward education about evolution, the governments of most countries utilize the life sciences, from agriculture to medicine, to support the survival of their citizens – knowledge about evolution is engrained in every aspect of the life sciences. Drug and vaccine testing for humans require prior testing in non-human primates because they are the genetically closest species; while those working with primates receive vaccinations equivalent to those for travelers to distant countries. The evolutionary proximity of species leads to similar physiology and cell biology, similar resistance or susceptibility to infections, and so on.

Recent studies in molecular biology have led to the sequencing of the genomes of (so far) 254 eukaryotes (including humans, chimps, dogs, bony fish, frogs, yeast, fruit flies and others), 378 bacteria (including many that cause human infections like pneumonia and Strep throat) and 158 Archaea bacteria that live in adverse climates like ocean vents (Wikipedia 2012). Universally, each of these sequences has confirmed that the relatedness of two species is shown in the sequences of genes that carry out specific functions. The more related two organisms are from a taxonomic perspective, the more related their genomes are. Mice and rats are more closely related to each other than either is to the dog, humans and chimps are more related to each other than either is to the marmoset, and so forth. This vast wealth of data (most of which is available on publicly accessible websites) provides perhaps the strongest evidence that evolution is the shared history of life on earth.

There is a unity of living creation that is a direct result of the common evolution of all of life on earth within the confines of our environment (Woloschak 2013, 2011: 209). Life on earth all shares the same elements (carbon, nitrogen, trace metals), the same processes (cell division, replication and repair of DNA, transcription of RNA, translation of proteins), even the same genetic code. These shared processes are sufficiently complex to make any two living organisms more similar to each other than to anything non-living in the universe. At the same time, life forms in different parts of earth have access to, and use for survival, different types of nutrients and energy sources, and are exposed to different environmental obstacles. Together, these challenges create selection pressure, which leads to specialization and speciation: features that make for a healthy organism in the equatorial rain forests are inadequate for survival in an oceanic thermal vent. Thus, mankind and every other species share something in common as they evolve into diverse forms. Both the unity and diversity of life have a profound theological significance that is missed if we do not incorporate the theory of biological evolution into our contemplation of Creation. Unity helps humanity to see the relationship of all creatures, and our relationship and separation from the earth itself. All of life shares its simplest ingredients with the earth, and everything more complex with each other. The diversity of creation helps humanity appreciate the need for all creatures, all of life, all niches and environments, to support each other and our planet. With both of these concepts come a profound ecological consciousness and a view of humans as guardians of creation.

The Relationship of Evolution and Ecology

Ecology is a "branch of biology that deals with the distribution, abundance and interactions of living organisms at the level of communities, populations, and ecosystems, as well as at the global scale" (http://www.biology-online.org/dictionary/Ecology, accessed 29 August 2012). The term is derived from the Greek words οίκος, which means household, and λόγος, the word for knowledge or study. The study of the human "household", the earth and its environment, and of how interactions with the environment play a role in the survival and development of living organisms, are the context of ecological study. The environment as an organism encompasses its "external surroundings including all of the biotic and abiotic factors that surround and affect the survival and development of an organism or population" (http://www.biology-online.org/dictionary/Ecology, accessed 29 August 2012). In sharing the same biotype with the rest of its own population and with populations of other species, an organism is a part of a wider biological community. The term "ecology" was first used by Haeckel in 1866 to describe "the comprehensive science of the relationship between the organism and its environment". It is considered to be a highly interdisciplinary field with interactions among areas including geology, geography, biology, population dynamics, statistics, and others. Eugenius Warming (1841–1924) is considered to be the founder of the field of ecology as a separate discipline of biology.

The link between ecology and evolution has long been recognized in academic circles: many universities have a single department of evolution and ecology, and studies in one discipline generally require coursework in the other. These two areas of biology are usually viewed as two different sides of the issue of organism-environment interaction. While evolution studies this interaction from the perspective of the population over time, ecology examines this same interaction from the perspective of the environment over time. There are numerous examples of how environment affects evolution and how organisms affect environment. The following examples "view" humans as a species in its interaction with the environment.

Perhaps one of the simplest examples of the interplay of biological environment and life is evident in the Great Chinese Famine that occurred between 1958 and 1962. In China at the time, there was a poor crop yield in the cooperative farms. The Chinese government blamed sparrows for the famine, alleging that they were eating up the food crops: as a result, an organized and massive destruction of sparrows occurred. In reality, the sparrows had kept the locust population in check and as a result of their near extinction in 1958, the locust population massively increased, destroying the crops at a high rate. This exacerbated the famine and gave rise to a large loss of human life. The ecosystem balance between locusts and sparrows was destroyed by humans who were not interested in the study of ecology, and who were focused on personal beliefs (Dikötter 2010: 333).

An example that illustrates the role of the environment in evolution is the example of sickle cell anemia and its relationship to malaria in humans. The sickle cell disease is caused by a single mutation in both copies of the beta-globin gene, which encodes a protein that transports oxygen in red blood cells. This mutation results in an atypical beta-globin molecule, which distorts the shape of red blood cells into a sickle, or crescent, shape. People who have two copies of the sickle gene die early of complications from sickle cell anemia; however, people with one healthy and one sickle gene have normally-shaped discoid red blood cells. More importantly, however, red blood cells with one half of sickle protein are resistant to malaria, a disease endemic in Africa and areas of the Mediterranean region, which was brought to the southern parts of the USA as well. In these regions, people with two copies of the healthy version of the gene die of malaria, while those with a healthy and a sickle protein do not succumb to malarial disease. In the present day United States, Western Europe and other areas where malaria is no longer found, there is no evolutionary advantage to having a copy of the sickle gene; it is only in areas where malaria is endemic that the sickle cell gene is actually beneficial to its carrier. Thus, the frequency of the sickle gene in non-moving human populations tracks the regions affected by malaria.

These two examples illustrate the interactions between the environment and evolution on human species, and demonstrate how difficult it is to understand one without the other. Rejection of the ideas of evolution, then, can lead to a misunderstanding of the relationship between organisms and their environment. Subsequently, such misunderstanding may contribute to a lax attitude toward environmental concerns: anti-evolution sentiment may develop into anti-environmental attitudes. In general, most serious scholars do not accept a literal understanding of scripture, and therefore should not have a problem with the concept of evolution.

Critiques of Evolution

Many critiques of evolution come from those who are fundamentalist in their views and have, for example, chosen to view the Bible (or other holy writ) as a literal truth. There are also those who have chosen to ignore scientific evidence and reinvent "science" without critical thinking and offer "alternatives to evolution" such as a new discipline they term "intelligent design". I have chosen to largely ignore those critiques mostly because many, including myself, have written and spoken on these topics previously (Woloschak 1996, 2011: 209; Buxhoveden and Woloschak 2011). Instead, I have chosen to address critiques based on arguments that have an appearance of "common sense" and which I have received as comments in response to articles I have written, lectures I have given, or discussions I have had with religious scholars about evolution.

What are these concerns regarding evolution discussed by religious scholars? Some are ideological, some are theological, and some quasi-scientific. I will give examples of each, again noting that this list is not complete but rather is an excerpt from a much larger collection. For example, I choose to ignore critiques of science in general as radical materialism, or those blaming biology for existence of social Darwinism. Both of these two types of arguments are confrontational without an interest in discussion, without which no argument can expect reception. Good examples of the three categories of "common sense" arguments against evolution are:

(a) "Evolution is based on chance, and a belief in chance is contrary to a belief in God."

(b) "Acceptance of evolution leads to our acceptance of human beings as just animals, leading to a lowering of our estimation of ourselves."
(c) "Science finds causes of events in the world. Where does God fit in if God is the Creator and Cause of all?"

I will take these issues one-by-one and attempt to discuss them in more detail.

The (Quasi-Scientific) Question of Chance in Science (and Evolution)

One source of anti-evolution sentiments is the fact that biological evolution depends in part upon "chance", and to some people it is unclear how God could work by "chance". Many want to assume that the process of Creation could not have come about by a chance process but must rather be a process (pre-)determined by God. The concept of chance, however, needs to be considered at several levels. All events that can occur in the world fit into the one of two categories: stochastic or deterministic. The word "stochastic" comes from the Greek word Στόχος ("stochos") referring to an event partially but not fully determined by the previous state of the environment. Such events are the subject of conjecture and randomness, and therefore look as though they are determined by chance. An example of this is the decay of a radioactive isotope. Each radioactive isotope has, as one of its properties, a half-life which defines how long it will take for it to decay. Despite that characteristic of the radioisotope in general, one cannot predict in which precise order the individual atoms of the radioisotope will decay. Thus, radioactive decay is a stochastic process. Opposed to stochastic processes are deterministic processes, which do not involve random phenomena. Processes described deterministically always produce the same output for a given starting condition. An example of a deterministic process is the genetic cause of disease: a person bearing two copies of the sickle gene will develop the sickle cell disease. Deterministic events have great predictive power for humans while stochastic events do not. Occasionally, additional knowledge about the prior conditions of events considered to be occurring by chance makes them predictable, and therefore deterministic. However, based on what is observed in the cosmos and on earth, it seems clear that both deterministic and stochastic events occur naturally in creation.

While most people think of evolution as occurring predominantly by chance, evolution, like most other physical phenomena, involves both deterministic and stochastic processes. In general, neither process entirely determines how a biological system behaves, and the interplay between deterministic and stochastic processes is complex and not readily understood. Only infrequent glimpses in the interplay between deterministic (for example, inheriting one, two or no sickle hemoglobin genes) and stochastic (for example, the possibility for contracting malaria) aspects of human evolution are afforded in today's science. Some features of evolution are determined in large part by stochastic processes – mutations in genes are often triggered by random enzymatic processes, often triggered by interaction with the environment. On the other hand, other processes, deterministic in nature (such as natural selection), also drive evolution. Both the generation of mutations (stochastic) and natural selection (deterministic) are processes which are essential for evolution: neither process is the only driver of evolution, and both depend upon each other and are multiply interwoven with each other. Without the introduction of "random" mutations which bring material advantage to their carriers, the natural selection process would become effectively random: without natural selection, the mutations would have no survival implications and their accumulation in a population would be random. In general, stochastic processes (which involve predominantly the occurrence of mutations) operate at the level of the individual, while deterministic processes (involving natural selection and thus the accumulation or elimination of mutations) occur at the level of the whole population. Evolution requires both processes, and together their effect is more deterministic then stochastic.

The human body cannot function without an intact immune system. How do our bodies manage to develop a method to fight every possible invading organism that might enter, given that there are trillions of possible foreign bodies that can invade and attack a human being? The immune systems of most higher organisms have a stochastic component that allows for a random generation of mutations and a subsequent positive selection of the "right" mutation to fight the infection within the body. This selection and amplification of the "fighting" immune cell clone occur in every person's body in response to foreign invaders. The stochastic process is the sparking of mutation, and the deterministic process is the selection of the proper protein that makes the immune system able to give us protection from foreign entities (Woloschak 1986: 581; Woloschak et al. 1986: 645). Thus, our bodies (as well as those of most higher animals) have evolved (deterministically) a stochastic approach to fighting disease; the stochastic nature of the immune system is also a part of creation. If stochastic processes in our body are natural, those that lead to evolution outside our bodies are as well.

The (Ideological) Question of "Animal Baseness"

Another issue that has been raised against evolution is the notion that to accept human evolution would "reduce" us to being "just" animals after all. Linked to this question, I believe, is the question of how to understand the story of Genesis, not so much from the literal story, but more from the concept of a primordial edenic state. The stories within Genesis (as used by all the Abrahamic faiths) point to some perfect state of creation that existed prior to humanity's fall from grace, at least as defined in the creation myths. What is Eden, if it is not the original state of humans? How can we reconcile the concept of Eden as a perfect state of "original" humans truly in communion with God, to the origin of humans from ape-like common ancestors? Are we to assume that these ape-like common ancestors were actually in communion with God and that when we became human (whatever that actually means) we fell out of communion with Him?

In looking at the problem of humans as animals, I would note that humans are animals. In fact, I would argue that there is some truth to the idea that animals are more true to what they are supposed to be, and thus more perfect, than humans. My dog is a better dog than I am a human being, and I would venture to say that this is true for most non-human species. Certainly, there are individual exceptions to this – there are animals accused of brutal killings – but I believe that most of these events are provoked by unusual circumstances. Humans kill without justification: we torture one another needlessly, and we injure ourselves and others with little, if any, provocation in some instances. I believe this is not what humans are supposed to be: we do not measure up to the standards of our species. This consideration of humans as animals always reminds me of a cartoon I once saw . . . . a human being is doing his night-time reading with a chimpanzee lying next to him, reading *The Origin of the Species,* saying "We're COUSINS? Well that's kind of gross" (http://popperfont.net/2012/05/14/were-cousins-well-thats-kind-of-gross-evolution, accessed 29 August 2012).

Sergius Bulgakov discoursed a lot on this question of Eden and the primordial edenic state, but before that let me introduce him as a religious philosopher and scholar. Sergei Bulgakov was a Russian-born Orthodox priest, and professor of dogmatic theology at the St. Sergius Institute in France. He was born in 1877, was forced to emigrate to Paris, and after a long professorship died in 1944. He wrote several books and articles examining the relationship of humans to nature, published in many languages both during his life and posthumously (Bulgakov 1937, 1972, 1988, 1993, 2002, 2003, 2004; Plekon 2005: 125). Most notably, his book *The Bride of the Lamb* examines the science-theology interface from an Orthodox perspective (Bulgakov 2002). In this book, Bulgakov examines Genesis, not as history per se but rather as a meta-history or even hyper-history: "To assert that the stories [of Genesis] are 'history' in the very same sense as empirical history is to do violence to their direct meaning, to subject them to critical mutilation[. . .]." He, like many more recent scholars, believed that there were deep truths within the Genesis stories.

Bulgakov recognized the issue of "the missing Eden" inherent in the Genesis stories as a stumbling block for contemporary thought, and in his book *The Bride of the Lamb* (Bulgakov 2002) he notes: "One can say that the remembrance of an edenic state and of God's garden is nevertheless preserved in the secret recesses of our self-consciousness, as an obscure anamnesis of another being[. . .]" (Bulgakov 2002). This anamnesis comes from the Greek word meaning "calling to mind" or "not having amnesia", i.e., not forgetting. What Bulgakov is alluding to is that Eden is a state to which we strive in our personal future, and not in our species' past. The Eden referred to is something human beings and all of creation strive for, not something lost in the past. Similarly, in the Liturgy of St. Basil the Great, during the anaphora the priest's prayers call for a remembering of things yet to come, by remembering not only the things past like the crucifixion, the resurrection, and the ascension, but also by remembering (or calling to mind) those things yet to be, such as the second coming. This is discussed below when we discuss causality and time.

Related to this question of human beings as animals and the idea of Eden, Bulgakov states: "[. . .]although man is phylogenetically connected with the animal world by his animal nature, his origin is not merely an evolutionary achievement, but an express and new divine creative act that is *outside* the evolutionary process. It is something *new* in creation" (Bulgakov 2002). The appearance of a godlike spirit in humanity is a mystery that is not understood empirically, and evolution does not attempt to define when or how this spirit first appeared in humans or human-like creatures, nor is it supposed to. According to Bulgakov, continued reflection on the animal nature of human beings can be useful, but in some ways it keeps us from understanding what it is that makes us human.

The (Theological) Question of Causality

The final question of causality is about the relationship of God to cause and science to cause. Evolution takes place in time and requires time. While processes that fall under the domain of chemistry and physics require time, this time is usually at the level of nano- to micro-seconds; however, processes in the fields of biology and astronomy require often large amounts of time. The evolution of life on earth has required billions of years and astronomical distances are calculated based on time – the distance that light travels in 1 year, called light years. While non-evolutionary biology and evolution experiments with very short lived organisms (bacteria, fruit flies) can sometimes generate experiments in real time, astronomy cannot do so. Evolution is a process that occurs only on a long time-scale: it is totally time-dependent, and it cannot be well-handled experimentally because such vast amounts of time are needed (and also because the deterministic effects of each possible mutation and processes of natural selection are not yet fully understood). Therefore, evolution is seen over many generations, and perhaps the only ways that it can be manipulated experimentally is with bacteria or fruit flies that have short generation times.

Much early science was oriented towards understanding God. Mendel, a monk of the Catholic Church, pursued genetics as a way of understanding nature and thereby obtaining a view into God's creation. Galileo peered at the stars to understand the universe in hopes of better understanding the One who created it. These early science perspectives were simple and linked to a "two book" model for understanding science and religion – with the "book of nature" and "the book of scripture" being two different approaches to understanding God and his creation. In this view, God was the source of all causality, and creation was a reflection of God's action in the universe. Modern science has distanced itself from any concept of a Creator, focusing instead on understanding intermediate causes or "sub-causalities". God is not present in this equation, and I would argue that this is a good thing because scientists have often shown themselves to be totally ignorant of God or theology.

I would also point out that the issue of causality is often a driver of human thinking and human pursuits. Tolstoy acknowledged this in *War and Peace* when he wrote: "The human intellect cannot grasp the full range of causes that lie behind any phenomenon. But the need to discover causes is deeply ingrained in the spirit of man" (Tolstoy 2006). This drive to find causes is found in all areas of investigation: in history, where we try to uncover the cause of events in hopes of not repeating mistakes: in psychology, where we hope to find the cause of mental disorders and thereby cure the patient: in medicine, where we hope to find the underlying cause of disease and give the appropriate therapy. The overall goal of science is to provide useful models of reality, and this is driven by the cause-effect relationship.

Scientists look at bacteria and viruses as causes of infectious diseases, psychological trauma as causes of mental disorders, and so on; but scientists do not attribute any aspect of this to God. In fact, while many people have complained that science is wrong because it does not consider God as a cause, there is really no need for God to be the direct cause of small individual events. Science attempts to be objective with the goal of uncovering a pathway or defining a chemical response: this provides a language and approach that is unified among all scientists, and that allows for communication across the globe and even across disciplines. When a biologist in Chicago and a biologist in Japan are talking about a particular response to radiation, they both know what it takes to define that response and whether the appropriate criteria have been met to establish that it is in fact a response to radiation. When journal papers are being peer-reviewed for inclusion in a particular journal, often the comments on the paper will be similar regardless of whether the review is from Germany or Canada. While many feel confused and even angered by the fact that scientists can discuss creation without putting God into the story, these same people do not understand that there is humility in not discussing God. There is a limit to what science can define, and that limit is based on the objective scientific approach of performing hypothesis-driven experimentation. God is not subject to such testing, and therefore if a scientist were to bring God into the discussion that would be based not on scientific experimentation, but rather on his or her personal belief system. Despite some who think that science can be used to prove the existence of God, most scientific scholars do not believe that the scientific method is amenable to such considerations. If scientists were to put God into their scientific results, one wonders what the basis for this would be and what criteria would be used for including some faith-based information and not other. In fact, it could be argued that much of the animosity in the science-religion discussion is based on scientists over-stepping their bounds and delving into faith-based comments. The issues of causality from a scientific perspective and those from a theological perspective become confused. As modern science finds scientific causes and pushes the cause of events (e.g. beginning of cosmos) further and further from God (as described by the "God of the gaps" above), God appears to be smaller, and one wonders whether God is even there.

One early proponent of "God as cause" was Thomas Aquinas who argued that God is the Primary Cause of all things: "There must be found in the nature of things one first immovable Being, a primary cause, necessarily existing, not created; existing the most widely, good, even the best possible; the first ruler through the intellect, the ultimate end of all things, which is God" (Aquinas 1948). This argument of Aquinas' has become a hallmark for the Western Church in defining the relationship of God and Creation with God as the Primary Cause and other causes as being secondary. At first examination, this statement of God as the Primary Cause of all seems well-based in reasoning and understanding, and in fact God could be placed as the Primary Cause of all things with science examining secondary causes. This, however, may lead to erroneous conclusions.

Sergius Bulgakov takes this perspective to task arguing that “The One Who Causes” is not a proper designation for God. He bases this on how we understand the word cause (Bulgakov 2002). When humans cause things to happen, we think about “cause-effect” relationships; for example, turning the key in the car ignition causes it to start, or exposure to the influenza virus causes a person to develop the flu. This is not the proper way to think of God’s relationship with the world. Bulgakov argues that the proper description of God’s relationship to the world is that of Creator and creation, and that this is not the same as “The One Who Causes”. If human creativity is somehow a micro-relation to God’s creativity and God’s creative activity, then perhaps we can understand God as Creator through considering our creative acts as humans (as opposed to causative facts). A comparison of cause-effect actions with creative actions actually shows that they are quite different. Creativity is often considered to be a mental activity that involves the generation of new ideas or new concepts, although there is great difficulty in defining it and its features. The source of creativity has been attributed to a variety of different processes (social environment, cognitive processes, divine intervention, serendipity, and so on) and it is usually multi-dimensional in nature. Creativity is not something that can be dictated or even defined, nor is it something that can be predicted (“Today I will be creative”). This is very different from a cause-effect relationship, in which the end-result can be easily attributed to a specific action. So, a person can easily say: “I will make a ___” and proceed to do it, if it involves no inspiration; but such is not the case with creation and creative thinking. While a person can indicate that they will design a particular experiment or a particular building at a given time, the inspiration for the creative component to that work cannot be dictated, and may come when least expected (or may never come). Thus, we often hear people claim that their best ideas (creative moments) happen in the shower or when they first wake up in the morning. If one then extrapolates from human experience with creativity, it becomes clear that creativity and cause-effect are very different things. Bulgakov provides a critique of aspects of western theology including arguments against the doctrine of first and second causes. He prefers instead a concept of “co-imagedness” in which the creatures contains the living image of the Creator, and he argues that the world does not have a cause since it was created and God is not the cause of the world but rather is the world’s Creator and Provider. In this sense, the world becomes a correlative unity understood by its connection with its Creator rather than an autonomous and unrelated entity. We can also easily understand this stand from our own creative experiences: things we have caused to be made are much less important to us than those we created drawing upon our inspiration, our originality. We are proud of such things, and want to be measured by them: in some way they are us ourselves. This is another meaning to be had from the word originality – when we create and are the origin of a creation, we are truly original. God as Origin of all is infinitely more than a cause. Bulgakov reasons that the proper relationship of the Creator and creation is expressed as an icon:

> In general, the idea of the Creator and creation does not need to be translated into the language of mechanical causality, for it has another category, its proper one, that of co-imagedness, since the creature contains the living image of the Creator and is correlated with Him [. . .]. The world does not have a cause, since it is created; and God is not the cause of the world and not a cause in the world, but its Creator and Provider. God's creative act is not the mechanical causation through Himself of the world's being, but His going out of Himself in creation [. . .] (Bulgakov 2002: 221–222)

This co-imagedness fits well with the Genesis context of humans being made in the image and according to the likeness of God. Humans bear the imprint of their Creator, the icon of God.

Concluding Thoughts: Lessons from Evolution

Based on everything I have noted above, I would now like to summarize some of these lessons from evolution. First of all, evolution tells us that we are related to all life on earth – through our history, our common origins, our shared genetic code, our proteins and pathways. While there is a diversity among life on earth that makes each species (and, indeed, each individual) unique, there is more that unites us than divides us, particularly as we compare phylogenetically closer and closer species.

The second lesson is that a failure to realize evolution as the origin of our species and of life in general leads to significant problems for humanity. Failure to recognise the strong relationship between evolution and environment, and the identification of the environment as an evolutionary force, leads to a failure to understand the proper relationship of creatures and their environment. This attitude can (and already has) led to small and large scale environmental disasters dangerous to the planet, to life on earth and to the survival of the human species.

Finally, a study of at least some of the critiques of evolution reveals that reflection on evolution can promote deeper understanding of the relationship of humans to the Creator and to creation as a whole. A better understanding of human beings as animals, human beings as unique within the animal kingdom, the relationship of the Creator to creation, and much more can be examined theologically and spiritually when discussed in the light of evolution.

Bibliography

Aquinas, Thomas. 1948. *Reasons in proof of the existence of God Summa Theologia articles II and II*. New York: Benzinger Brothers.

Behe, Michael J. 1998. *Darwin's black box: The biochemical challenge to evolution*. New York: Free Press.

Bulgakov, Sergius. 1937. *The wisdom of God: A brief summary of sophiology*. London: Williams and Norgate.

Bulgakov, Sergius. 1972. *Sergius Bulgakov: A Bulgakov anthology*. London: SPCK.

Bulgakov, Sergius. 1988. *The Orthodox Church*. Crestwood: St. Vladimir's Seminary Press.

Bulgakov, Sergius. 1993. *Sophia: The wisdom of God*. Hudson: Lindsfarne Press.

Bulgakov, Sergius. 2002. *The bride of the lamb*. Grand Rapids: Wm B. Eerdmans Publishing.
Bulgakov, Sergius. 2003. *The friend of the bridegroom: On the orthodox veneration of the forerunner*. Grand Rapids: Wm B. Eerdmans Publishing.
Bulgakov, Sergius. 2004. *The comforter*. Grand Rapids: Wm B. Eerdmans Publishing.
Buxhoveden, Daniel, and Gayle E. Woloschak. 2011. *Science and the eastern Orthodox Church*. Farnham/Surrey/Burlington: Ashgate Press.
Darwin, Charles. 1859. *On the origin of species by means of natural selection, or the preservation of favoured races in the struggle for life*, 1st ed. London: John Murray.
Darwin, Charles. 1871. *The descent of man, and selection in relation to sex*, 1st ed. London: John Murray.
Dikötter, Frank. 2010. *Mao's great famine: The history of China's most devastating catastrophe, 1958–62*. New York: Walker & Company.
Dobzhansky, Theodosius. 1973. Nothing in biology makes sense except in the light of evolution. *American Biology Teacher* 35 (March 1973), reprinted in *Evolution versus creationism*, ed. J. Peter Zetterberg. Phoenix: ORYX Press.
Douglas, J. Futuyma. 1997. *Evolutionary biology*. Sunderlandm: Sinauer Associates.
http://popperfont.net/2012/05/14/were-cousins-well-thats-kind-of-gross-evolution. Accessed 29 Aug 2012.
http://www.biology-online.org/dictionary/Ecology. Accessed 29 Aug 2012.
Peacocke, Arthur. 2001. *Paths from science towards God: The end of all exploring*. Oxford: Oneworld Publications.
Plekon, Michael. 2005. Still by Jacob's well: Sergius Bulgakov's vision of the church revisited. *St. Vladimir's Theological Quarterly* 49(1–2): 125–143.
Smith, John M., and Szathmáry Eörs. 1999. *The origins of life: From the birth of life to the origin of language*, 81. New York: Oxford University Press.
Tolstoy, Leo. 2006. *War and peace*. New York: Viking Penguin.
Wikipedia, List of Sequenced Eukaryotic Genomes, List of Sequenced Bacteria, List of Sequenced Archaea. Accessed 21 Aug 2012.
Wilson, David S. 2002. *Darwin's cathedral: Evolution, religion, and the nature of society*. Chicago: The University of Chicago Press.
Woloschak, Gayle E. 1986. Comparisons of heavy chain isotype expression in Peyer's patch and splenic B-cells. *Molecular Immunology* 23(6): 581–591.
Woloschak, Gayle E. 1996. *Beauty and unity in creation: The evolution of life*. Minneapolis: Light and Life Publishing.
Woloschak, Gayle E. 2011. The compatibility of the principles of evolution with eastern orthodoxy. *St. Vladimir's Theological Quarterly* 55(2): 209–231.
Woloschak, Gayle E. 2013. Perspectives on orthodoxy, evolution and ecology. In *Toward an ecology of transfiguration: Orthodox Christian perspectives on environment, nature, and creation*, ed. John Chryssavgis and Bruce V. Fotz, 263–275. New York: Fordham University Press.
Woloschak, Gayle E., T.B. Tomasi, and C.D. Liarakos. 1986. Identification of the major immunoglobulin heavy chain Poly A+ RNA in murine lymphoid tissue. *Molecular Immunology* 23(6): 645–653.

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