Understanding Evolution − Conversations Between a Scientist and a Pastor

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June 15, 2019

Over the course of the past few years, I have participated in occasional conversations about evolution with a local pastor. When directly quoted, the pastor's comments are provided in *italics* and my responses in Roman type. The materials that follow are compiled from several conversations and each one is titled with a Roman numeral to indicate different series in the conversation and different issues dealt with in each. Each of these series may contain several exchanges, but they all are part of a give-and-take that began with a couple of particular questions or comment from the pastor so they are combined into a single section.

I. **Dear Pastor:**

Thank you for the opportunity to discuss with you the topic of evolution and your church's doctrines on faith and science. I see in your correspondence two issues for us to consider: (1) your offer to come to visit my classes and lecture on evolution, and (2) some of your objections to evolutionary science and its outcomes (which I infer that you wish to bring up in your presentation to my classes). So, let us start our conversation with these points.

As to the first, I would be willing to have an exchange with you: you would address my classes and I would address your congregation in return. However, I would insist that we do this from our own strengths and expertise. That is, you might explain to my classes why you think that evolution is not concordant with your church's doctrine or practice of faith; and I, in turn, would explain to your congregation the scientific basis of evolutionary sciences and the shared goals of these scientists and people of faith: feed the hungry, heal the sick, free those that are enslaved or oppressed, make childhood safe, and so on. It would really be of little benefit to either my students or your congregation to have you lecture on biology and me lecture on theology.

Part of my reluctance is based on the material that you included in your note. Some of the statements and examples show that you have been misinformed about various aspects of evolution, and thus your conclusions about the effects of this science on our society are incorrect. It is not unreasonable for you or your congregation to have questions about evolutionary science, so I am happy to answer those. But to begin with, we have to be sure that the information that we are using in our conversation is correct. In particular, these errors manifest themselves in your example of the evils of Stalin's rule in the USSR. Your argument was based on the idea that Stalin's evil was a consequence of his belief in evolution—or at least that accepting evolution allowed him to justify his evil behavior. Let's begin with our agreement that Stalin's policies produced evil outcomes: death, suffering, starvation, loss of personal freedom—the list goes on. We tend to view a person whose whole professional life is tied up in such evil policies as someone who, if not actually evil himself, certainly has lost touch with morality and human decency.

However, your argument fails on one essential fact: Stalin despised Darwinian evolution; he felt that it was too “capitalistic” and he supported alternative models of biologic change. A lot of the failed agricultural policies, for example, were based on an anti-Darwinian model proposed by Lysenko which resulted in massive and persistent crop failures. So, if Stalin was evil, it was not because his embrace of Darwinism led him to it. Therefore, there can be no link between evolutionary science and Stalin's evil policies and actions; this evil existed quite apart from any acceptance of Darwinian evolution.

You might be equating Stalin's atheism with evolution, which is a common connection that people with religious objections to evolution raise (and also that some atheists use to justify their atheism—you will see that I believe both of those positions are incorrect). Of course, there are numerous scientists—including many evangelicals—who continue to be active in their faith practices while accepting and even pursuing research in evolutionary science. So, this connection is also incorrect.

Furthermore, if evolution is uniquely associated with evil in the world, then we would have to argue that there was no evil before 1859. Yet, we have both secular and religious examples that tell us this is not the case. That position, of course, puts the lie to many aspects of Genesis 1 and the subsequent history of Salvation—all of which unfolds because of the presence of evil in the world.

However, in my discussions with young people of faith on campus and in the community, I have found that this inferred link between evolution and atheism comes from a deeper issue: they argue that God is the source of all morality and the antithesis of evil, so that good, moral behaviors (or institutions) cannot exist without God. Indeed, what Genesis tells us is how people who turn away from God can be entrapped by evil. And yet, so much of our early Christian theology had its basis in the work of Aristotle, and he would be surprised to be accused of being without moral principles to inform right action simply because he did not know and acknowledge the God of the Bible. So, even if God is the source of all morality and the fight against evil, the historical record seems to indicate that moral people and moral actions exist even among those who do not recognize the source.

The other problem, of course, is that humans throughout history have often convinced themselves that their actions and policies—even when they cause great suffering and destruction—are sanctioned by God. Remember that the Nazi Wehrmacht troops (and their predecessors in other Germanic armies) used the slogan “Gott mit uns” (God is with us), even as they committed unspeakable acts of cruelty. In a less serious example, in my home state we poke fun at the annual football game between two Roman Catholic universities, calling it the “Jesuit Bowl”; presumably both sides are offering their prayers for success to the same source! This tendency to decide on a course of action and then conclude that God is behind us is the essence, I think, of the admonition in Matthew 7:21 ("Not everyone who says to me, 'Lord, Lord,' will enter the kingdom of heaven, but only the one who does the will of my Father who is in heaven" [NIT]). At least fans do not accuse the other team of unspeakable evils, even if they feel their assurance in Divine support and blessing is incorrect.

So, to start this conversation, we need to untangle the principles and foundations of evolutionary science and separate them from the inferences and judgments about their effects on human behaviors and human cultural and political institutions. Then later, we can look at specific concerns you have about modern society if you like. In summary, Stalin was not a fan or follower of Darwinian evolution; therefore, we cannot blame the evil in his regime on his adherence to evolution. Stalin was an atheist, for certain, but like many, his atheism was not driven by acceptance of evolution, nor is atheism required to accept evolutionary science as a useful and successful human pursuit of knowledge of how the natural world operates.

Going forward, we can continue to focus on these issues of good and evil, but I think it might be more productive to work out the details of the history, nature, and practice of evolutionary science. That is where I can be most useful to you, I think. And I hope that getting those issues straightened out may result in some reframing of your concerns so that you are responding to evolutionary science as biologists understand it and not to a caricature of contemporary biology.

Yours,

AJ Petto

II. **Dear Pastor:**

Thank you for your feedback and your next set of questions. At some point, it would be worthwhile to discuss your specific objections to biologic evolution itself, because I get the impression that there is more to your concerns than what you understand the science to be. The issue in human society and institutions is always what we make of the knowledge we have; that is, how we apply that knowledge in the world. And, although science itself is often perceived to be amoral, scientists recognize that they are members of society and that they have the same obligations as other citizens to make the world a better place.

People as different as paleontologist Niles Eldredge and the late governor of New York, Mario Cuomo, made this point in their public remarks: we all share the duty of making the world a better place by applying our skills and knowledge. We succeed when the results make the world a better place; we fail when our discoveries are misused to increase suffering.

In this light, evolutionary science falls mostly on the success side. It has been used to improve agricultural yields, develop vaccines and other treatments to prevent disease, providing new insights into how our bodies work, to understand how energy flows through environments and how to distribute it, to learn how changes in the environment are experienced by organisms and the resulting effects of these changes in terms of survival and sustainability of the organisms sharing an ecosystem—the list goes on.

But the important thing is that evolutionary science—as with ALL science—is ongoing; we do not get a little bit of information and have all the answers revealed, but we have to keep searching and looking for a deeper and broader understanding. And this is why we keep at it: there are more questions to answer and more things to learn.

But, for now, we have a place to begin. I will excerpt specific comments you made and place them in ***bold italics***, and then I will place my reply immediately after. In future correspondence, we can address follow-up questions or issues arising from the earlier conversation.

To begin, we need to come to an agreement about what comes under the heading "evolution". One of the important constraints of having a critical discussion is to arrive at a shared understanding of the fundamental concepts in the field we are discussing; in this conversation, of course, we are referring to biologic evolution. The key is to start with the ways in which evolutionary scientists understand and define their field of inquiry and the important concepts in it. It is reasonable to ask scientists to explain and defend their understanding and practice of evolutionary science, but we cannot demand that the scientists defend concepts and definitions that are not compatible with disciplinary understanding; we need to avoid the so-called “straw-man" argument fallacy or other rhetorical devices meant to score points in a debate, but that have no real relationship to the issues at hand.

In response to my question, you described your understanding of evolution this way:

An explanation of everything from a "big bang" to everything we see today. I think your side prefers a more limited definition, gradual change over time and does not want to deal with origins. You may correct me if I am wrong.

Yes, this definition is an incorrect, though not an uncommon, misconception about evolution. The definition of biologic evolution is not just a "preference" among scientists, but a carefully constructed framework that we use to make observations and collect data, to test our ideas against experiments and other research in the real world, and to develop ongoing research to improve our understanding of the history and variety of life on Earth.

When we have a discussion of the science behind biologic evolution, we don't get to choose which definition we prefer. To do so would condemn any conversation to futility. So, let me begin by reviewing the ways that scientists view this field of study.

Evolution as understood by modern evolutionary science begins *after* life exists; as a theory, it aims to guide research into the history of life on Earth, and the various forms that life has taken in time and space throughout its history on Earth. Evolution is indifferent to how the universe began or even how life first appeared on our planet. It is true that those issues may have implications for evolutionary science, but they are not critical to the evolutionary foundation of modern biology. In summary, evolution is indifferent to exactly how life, the universe, and everything originated; rather it is the study of how life on Earth has changed since it first appeared. Of course, science expects that there is a natural explanation for these phenomena, even if we do not have all the details we would like about how they occurred.

Second, it is a valid complaint that we use "evolution"—even in biology—in several ways. It is, unfortunately, a consequence of talking to ourselves that one sees in many disciplines; *WE* can tell from context which way we are using the word, even if it is not always obvious to others. So, to clear this up, let me give you the basic list.

1. **The "record" of evolution:** this refers to the observations that life forms exist today that did not in the past; and some of those that existed in the past do not exist today. In addition, there is a specific, observable, and consistent pattern of the appearance and disappearance of specific life forms that conforms to a general history of life on the planet (and this now also includes genetic and molecular sequences).
2. **The "process" of evolution**: this refers to the ways in which biologic change occurs within and among populations. These are the processes or the mechanisms that can provide the source(s) of the changes observed in past and among (and within) current populations of organisms. These include changes in the DNA, but also other processes—mating behavior, migrations, habitat choices, geophysical changes, and so on—that can result in biologic differences among populations of organisms.
3. **The "theory" of evolution:** this refers to the main organizing idea that all organisms are related through descent with modification from a population of common ancestors. As a result, we expect in general that the amount of variation among populations will correspond in general to the length of time that has passed since they split from others that share the same common ancestry and to the nature of the processes of change that have produced this divergence. The main role of the theory is to provide a program for research—to allow us to ask questions and learn more about the items in **#1** and **#2** above and then to test our models and understanding of how **#2** could produce the observations that we see in **#1**. This is what a theory is supposed to do; it is not just an "explanation" for explaining our observations, but a framework that allows us to make a specific test to verify or disprove predictions that we make on the basis of the theory.

These three aspects of evolution together form the construct I refer to in this conversation as "evolutionary science": the basic facts on the ground, the processes of biologic change that we have come to understand, and the theory that allows us to apply this knowledge to generate productive research.

The power of evolutionary theory is how easily it could be proven wrong: it predicts that biologic variation among organisms will fit a pattern—often described metaphorically as a "tree" with branches representing shared descent from common ancestors. Its power is in that only ONE arrangement of the biologic features is possible: those most closely related by common descent must share more unique biologic features with each other than with others who are more distantly related. Any finding that this is not so would immediately put evolutionary theory (evolution **#3**) into crisis. So far, 160 years after Darwin, no research has produced this fatal finding, but, in contrast, each new field of study has added another line of evidence that biologic variation among populations of organisms on Earth conform to the ONLY arrangement that could be produced by evolution by descent with modification.

Of course, there are other modifications in life forms that are driven less by ancestral features than by strict environmental conditions. That is why flying and swimming animals, for example, have a lot of similar features that are not inherited from the same ancestors that produced these features in other lineages. For example, fishes, marine reptiles, and marine mammals all share a small range of body plans to increase efficiency in swimming.

Part of the problem is that "evolution" is a "term of art" within biology disciplines—it has these specific meanings to biologists. Unfortunately for the understanding of evolutionary biology, "evolution" is also a word that has other meanings both in non-biology scientific disciplines and in the general lexicon, some of which are specifically contradictory to the way that the term is used in biology.

Natural selection, which you mention (somewhat incorrectly) below, is one of the mechanisms that we understand can produce the sorts of biologic changes required of evolutionary change, and Darwin used artificial selection as a metaphor (or maybe exemplar) of how changes could occur in evolution **#2** to generate divergence among descendants from a population of common ancestors. We now know that natural selection plays an important role in producing the evolutionary patterns that we see in evolution **#1**, but we also know today that there are many processes of biologic change (evolution **#2**) that provide the raw materials for natural selection.

You can get a basic overview of how contemporary science views evolution at the *Understanding Evolution* website's evolution 101 series: https://evolution.berkeley.edu/evolibrary/article/evo_01.

So [a local company] that focuses on livestock production says that through selective breeding each generation of hog is a little bit better than the previous one.

1. Though "a little bit better than the previous one" is a common description of the goals of selective breeding (artificial selection), there are several problems here in trying to apply this perspective to evolution in Nature.

    (a) Selective breeding was a principle long before anyone knew about the details of genetics. With our growing understanding of genetics, and later DNA, we learned HOW the process works—the preservation or elimination of specific physical characteristics that are encoded in the DNA and expressed through the interaction of this DNA with the process of development and the interaction with the environment. The DNA is the starting point, but it is not the entirety of the process. In essence, this is an example of the success of evolutionary theory—to show that evolution **#2** can produce the sorts of changes in populations of organisms that evolution **#1** requires.

(b) "Better" is a relative term; for selective breeding, there are specific goals in mind. Think, for example, about horses or cattle (I am not as familiar with pigs). Some horses are bred selectively to be racers, others to be draft horses, others for other qualities. Same with cattle; some are for dairy production, some for beef production, others as work animals. Which characteristics would be "better" in a selective breeding program depends on what the goal of the breeding process is. In Nature, what is better is what works for the survival and successful reproduction of individuals in the population.

...the goal is a pig that produces more and better meat with less food and water and in a shorter time period. The [company] use[s] computers to try and track each hog so they can see very small changes which is quite a task and open to lots of variables but the goal remains the same, better pig and a lower cost.

And your comments about the pig production reflect that there is a judgment about what "better" means—more meat of a higher quality in a shorter time with less investment for a better profit. However, we also know that some husbandry policies—dependence on antibiotics, for example, or the use of highly specialized feeds—do not, in fact, "*improve"* the pigs in any way that would enhance their survival in Nature, so this is a "better" outcome only in view of a very narrow context; and, in a sense, it is an evolutionary dead end. After all, any biologic changes that made a pig better to eat in a shorter time might be what we call "maladaptive": a change that results in shorter survival time or reduced lifetime reproductive success. After all, in Nature, natural selection would favor those variations that make the pig *less* likely to be someone else's meal.

And that is the chief difference between artificial selection (or selective breeding) and natural selection—and where the metaphor breaks down: selective breeding improves the animals" usefulness to humans and has no regard for the ability of the organisms to sustain itself in Nature (just look at the bulldog).

Of course at the end of the day, it's still a pig and the process is intelligently designed using scientific information.

If by "intelligently designed" you mean that the actions are guided by a specific purpose or goal,7 then this process certainly qualifies. If you mean that ultimately this process benefits the domestic pig species and improves its chances for survival in Nature, then, I would disagree.

The other part of your statement (it's still a pig) is a tautology. It is still a pig because the goal of the process is to make a pig with a few specific qualities. But this pig is not the same as the first domesticated pigs, or even the first pigs brought to North America by Europeans, or the wild populations of "pigs" that exist in Nature throughout the Old World. These "pigs" have changed—in some cases dramatically in biologic, behavioral, and environmental features.

So, your example of the biologic changes brought about by selective breeding is a great example of evolution **#2** above: the biologic processes that produce change. The difference is whether the change occurs for a specific, long-term goal, or whether the goal is more immediate—survival and reproduction in a specific environment—which is the foundation of the model of evolution by natural selection. The "goal" of natural selection—such as it is—is more immediate and short-term, and there is no imperative to preserve any individual or any species in the long run (indeed, over 95% of all the species we know are extinct) or for evolution to produce a specific species with any particular characteristics. There is, quite plainly, no required progression or end point in evolutionary change (indeed both now and at all the points in the history of life that we have been able to study, MOST of the biome consists of bacteria; more complex life is both rarer and far less abundant).

Another problem is that you are using a common misunderstanding of evolution that "something should change into something else", but, again, that is not the way that biologists understand the process. Even though there clearly is a time in the history of life where what we could call "pig-like" organisms did not exist, evolution does not propose that some other modern mammalian species produced a pig or pig-like descendant; the earliest known examples of pigs as a defined group are found at the same time as most of the other mammalian lineages emerged from the shadow of the reptiles that dominated life on earth in previous eras. What we do know (evolution **#1**) is that there is a time in the history of life when there were no pigs, and then a time in the history of life when there were organisms that appeared pig-like, and then a time when different distinct types of pigs became common and spread around the world (and, of course, the new studies on the pig genome using both domestic and wild pigs point to the same timeline of the emergence of the pig lineage we recognize today, even though the anatomy of those earliest "pigs" is different in several significant ways from their more modern descendants). We recognize these mammals as pigs because they exhibit some anatomic features that are found in no other mammals *except* pigs and their immediate ancestors (and, of course, we recognize these pigs are mammals, and vertebrates, and animals, etc. because they retained critical features that are shared only with other mammals, and vertebrates, and animals, and so on).

We do not expect, nor does evolution predict, that the pigs around us (wild or domestic) will turn into some other species. The history of life tells us that it is more likely that pigs as we know them will become extinct and that pigs (as well as other mammals) will be replaced in the future by descendants of some other lineage—which is what the history of life (evolution #1) shows us has happened before when the opportunities and challenges of the environment change: the emergence of amphibians after the age of fishes, the emergence of reptiles after the age of amphibians, the dominance of dinosaurs at the end of the age of reptiles and the emergence of birds at the end of the age of reptiles, and most recently, the emergence and dominance of mammals at the end of the age of reptiles (and, still, bacteria are the most common type of organism, and beetles remain one of the most diverse groups of complex living organisms).

The history of life on Earth is the patience of what is "waiting in the wings"—the story of the "understudies", as it were, that come to the center stage only when an unpredictable and often unexpected opportunity presents itself. The lead actor does not "turn into" the understudy; and the play may only be changed subtly at first when the understudy takes over, but it is changed and takes on a new direction.

My problems with evolution are many but could be mainly how it is so glossed over with statements like "evolution is true"; "98% of scientist believe it is true" when, as you have suggested, the definition/parameters are left unstated. Defining the term is important.

Well, first of all, please be careful of the "B" word (*believe*). It is used in scientific communities differently from how it is used in faith communities. It is more accurate to understand this word in scientific context as "accept" or "have confidence in", but it is always subject to modification based on the outcome of research and analysis. There is no value placed on holding to any scientific idea or understanding of natural processes when the evidence shows that it is clearly contrary to what we can observe in the natural world.

This is how scientific ideas change—why we do not continue to experiment with alchemy, for example—and why we are committed to an understanding of geology that is *not* the consequence of a single worldwide flood, and why we are convinced that processes of biologic change that we have uncovered and can observe in the field and in the lab are responsible for the history and variety of life on Earth. However, our understanding about these processes (evolution **#2**) and about how they produce the record of evolution (evolution **#1**) is different from what Darwin understood, because we used his theory of descent with modification (evolution **#3**) to conduct research into the questions about how evolution **#1** and evolution **#2** relate to each other.

The reason that scientists accept evolution is that it works as a way of organizing our understanding of the history of life on earth and of the similarities and differences among life forms. It also is a prediction of how life forms ought to be related (at all levels, including down to how the DNA is organized). In essence, each and every scientific study that we do about the history and diversity of life on Earth is a test of the hypotheses generated by evolutionary theory (evolution **#3**) and our understandings of the processes of biologic change (evolution **#2**) applied to the evidence of existing variation in the current and past populations of living organisms on Earth (evolution **#1**).

The basis for the solid support and acceptance of evolutionary theory among scientists is that the research in the past 160 years has failed to provide any scientific basis for rejecting biologic evolution—even as scientific progress has given us new ways to study biology and new ways of analyzing and interpreting biologic variation. Instead, it has given us more examples of how the pattern of variation in life on Earth (evolution **#1**) is arranged as predicted by descent with modification.

Yes, the specifics of how biologic processes produce evolutionary change (evolution **#2**) have been modified and expanded by new research, but that tells us that this is not simply a creed or statement of faith among biologists—Darwin's *On the Origin of Species* is not treated as a scriptural text to which all scientists must pronounce loyalty or affirm as a tenet of faith. Indeed, evolutionary scientists have incorporated over a dozen major findings of how biologic change works (evolution **#2**) that Darwin did not and could not have known in the mid-19th century (including how inheritance works and the role of DNA). And there are more that are still being tested. This research has strengthened and reinforced evolutionary models—not weakened them.

And this is why biologists overwhelmingly accept evolution **#3**—it continues to produce successful and valuable research to help us understand the way that life on Earth works; it is considered “true” in this sense—as is the case for *all* scientific theories. Indeed, it even makes your example of selective breeding in pigs a more effective application of evolutionary change than the old way of just eye-balling potential sires and dams and picking the ones that the farmer thinks might embody the features desired in the next (or some future) generation. Meanwhile, natural selection continues to work on wild pig populations that continue to differ from their domestic relatives—even, or especially, without any purposeful intervention from geneticists and breeders.

Yours,

AJ Petto

III. Dear Pastor:

You had raised the issue earlier of the origin of life and what that meant for the study of evolution, and I asserted that evolution (**#1–3**) is indifferent to how life began because the goal of evolutionary science is to understand the history and variety of life on Earth. Evolution begins after life as we know it emerges on Earth. How it got here is an interesting question, but if we had no idea of how life began, evolution (**#3**) would still be a valuable theory because (a) it continues to support new research in to how life varies and changes; and (b) because it generates new questions and ideas for future research. Not knowing the origin of life has no effect on the usefulness or the value of evolutionary science.

You call my first observation regarding the origin of life the "straw-man" argument that you call a logical fallacy.

The argument is not a straw man because of the mechanisms or the questions about how life first began; it is a straw man because this argument takes a point of attack against claims not made by biological evolution. Evolution is about how life changes over time, not about how it first began. So, insisting that evolutionary scientists defend some principle or conclusion that evolutionary science does not include in its own definition of the field of research is a classic straw-man argument.

It would be as though I asked pastors to defend doctrinal principles by insisting on using materials from the texts of the ***Apocrypha***. Because most mainline Christian churches do not see these books as canonical—even if they do raise interesting questions—they are not the foundations of contemporary doctrine or theology. Therefore, it would be wrong to claim that any doctrines or dogma that Christians proclaim are necessarily invalidated for their failures to account for the materials in these writings in their theology.

That is a big and legitimate question. Starting at life but not including something about how that life became life seems lame.

Not really; think of it in terms of the theory of gravity. We have no idea *why* gravity exists, why it works the way that it does, or how it came to be, but that does not prevent us from successfully applying the principles of gravitational forces and attractions in everything from roller coasters to airplanes to water slides to space craft, and so on. Our understanding of how gravity affects things large and small is not impaired by not knowing its origin.

And, just as with studies of the emergence of first life, there is ongoing research into the origin of gravity. We just do not have the answer to that THAT question—yet! However, not knowing EVERYthing does not mean that we cannot know ANYthing. We know a lot about gravity and we know a lot about evolution. Yes, these are still *very* interesting questions and the subject of a great deal of scientific research, and the result is that some of the answers are starting to coalesce. But even without knowing the specifics of these answers, we can figure out how to throw a ball between the pitcher's mound and home plate or figure out which genes are responsible for which proteins and how those proteins affect the organisms that produce them.

But I will start with a question about what that first/earliest life form looked like.

Well, of course, we do not know. As of yet, the *earliest* forms of life we have identified are almost certainly not the *first* ones. Both the time that has passed since the first life appeared on earth and the nature of the geologic process that govern preservation and discovery of these life forms are very serious challenges to overcome. Still, we do appear to be working backward toward that first life—both in identifying earlier and earlier life forms in the fossil record and in conducting research in the laboratory about how some of the characteristics of living organisms relate to the chemical and energetic environments that existed at the time that the first such organisms appeared.

It is likely that, given the differences between the environments at the time and the environments later in the history of the Earth, that these "organisms" were quite different from what we see and know today and in the fossil record we can observe (back about 3.5 billion years). It is not that these organisms had to *look* a certain way or even at all like what we can see as the biologic plan that seemed to have emerged at 3.5 billion years ago and became the basis of modern life; that is, plan in the sense of overall structure and function, not in terms of purpose.

What in your understanding was that first life form?

I can tell you only in general terms, not in specific ones. All existing life on Earth has certain characteristics: it is cellular and at least semi-isolated from its surroundings, it reproduces, it responds to the environment, it is organized, it undergoes development, it captures energy and directs it to the process of maintaining its structure and the functions required for life (referred to generally as "autopoiesis").

So, these are the things that the first life would need to be able to do, even if for only a very short time. At a minimum, autopoiesis would need to be achieved; and this is the thing that separates life from non-life. But, as far as I am aware, there is no good answer for what form this first life would take or whether it is necessary for *all* these characteristics to be present at the outset.

Would it make sense that the same process that changed that first life form into more complex and varied life forms was the same process that could have led to that first form?

It is one line of argument, but it is not a necessary condition. There are some models that are analogous, but evolutionary processes rely on the ability to transmit inherited characteristics (the characteristic of reproduction)—even if how that is accomplished is nothing like the process that we observe in living organisms today. We suspect that the first basic living organisms used forms of RNA for the process of inheritance, and we now have evidence that some existing life forms also use RNA for a variety of other physiologic functions, too.

So, given that we know that there are self-organizing non-living entities in Nature, once they had the physicochemical ability to persist for more than a few seconds, those that were able to persist longer could become the framework for adding other characteristics that enabled even longer persistence or the ability to enhance organization of similar entities in their immediate environments as they achieve some sort of stability.

In one sense, this is generally a model LIKE natural selection, but until there is a way to transmit hereditary characteristics, it is not the model of descent with modification that Darwin proposed as the foundation on which evolution by natural selection proceeds.

In short, we have interesting models to explore—that is what a good scientific theory does for us—but we do not have the answers—yet.

I did talk with a guy at [local company] about their work with any gene editing to get the better pig but he indicated that they did not, and [they] were only looking at the pig as an economic entity.

Well, again, the issue is the definition of "better", isn't it? If it makes more money for the company, then it is "better" in that one sense. If it means that you get more bacon, then you would agree that it is better (if your goal is to have more bacon). But "better"—like the concepts of adaptation and natural selection in evolutionary theory—are contingent and relative terms dependent on the environment in which the organism operates. It is never absolute.

One of the main objections to evolutionary theory from the general public is its lack of purpose and pre-ordained direction. In biology, we often describe this as "randomness"—another term of art that needs further explanation.

In mathematics (and in games of chance), "randomness" means that every possible outcome is equally likely. We used to think that true randomness described all genetic mutation (substitution of one chemical constituent of the DNA for another). This does happen, but now we know that not *all* substitutions are equally likely, and not all substitutions have the same impact on the organism.

However, the interaction of this genetic change *can* affect how individuals with different characteristics can be successful in life, and natural selection works to test the relative benefits of these variations among individuals. Natural selection is, then, a sort of a filter that affects which of these organisms containing which of these genetic changes will be passed along to future generations.

This is what we mean when we say that evolution (**#1**) is a contingent result; the record we observe is the result of changes *within* organisms tested against the *external* natural conditions in which they live. If those conditions change—for example if the global temperature warms or cools or weather patterns change—then biologic changes that made one successful in, say, the Arctic Ocean might not be the key to success when the water temperature increases. This is why we are seeing more "southern" species showing up farther and farther north (for example, tropical parasites and their vector species as far north as Delaware); they are already selected for success in warm climates, and they are moving north with the changes in average temperature.

So, "better" does not exist in evolutionary science outside of the specific conditions in which organisms must live. Unlike the pigs in your example, there are plenty of situations in which slow growth and smaller body size is an advantage in Nature. So, the judgment we make of what is better or worse in biology is always dependent on the specifics of the environmental conditions.

Yours,

AJ Petto

This is the end of our correspondence to date (June 1, 2019). Further updates will be added as the conversation continues.

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