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Science and Religion: Friends or Foes?

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Some Latter-day Saints and others presume that science and religion are mortal enemies. However, they have much in common. What's more, in Latter-day Saint discourse there is no such thing as a miracle completely beyond natural law, so there is no need for "war" between science and religion. Still, many are troubled by scientific studies regarding the origin of the earth and its inhabitants that appear to differ from scriptural accounts. But upon careful examination of the relevant issues in areas such as biblical scholarship, the origin and evolution of life, and Big Bang cosmology, it is clear there is no need for conflict.

We often read that science and religion are enemies, pitched in a life-or-death battle for the minds and hearts of the public. There is some truth to this. Some scientists and secular scholars are outspoken opponents of modern religion, arguing that religion is fundamentally irrational and even harmful. Some religious writers perceive science as a mortal threat to religion and believe it their solemn duty to oppose science at every turn in the public arena.

Yet, from a fundamental point of view, surely there cannot be any war between the two disciplines. Both are part of a fundamental quest for truth. Both espouse the "idea of progress," which American sociologist Robert Nisbet defined as the notion that "mankind has advanced in the past, is now advancing, and may be expected to continue advancing in the future,"[1] a definition remarkably similar to the ninth article of faith. Both scientists and religious persons can stand in awe at the natural world and the universe

we inhabit, which is now known to be far more vast and more magnificent than we realized, based on discoveries just in the past two or three decades.

Science Defined

Much of the perceived conflict derives from confusion over what science is and what it is not. Perhaps the most succinct definition of science is the one given by the National Academy of Science: "*The use of evidence to construct testable explanations and predictions of natural phenomena, as well as the knowledge generated through this process.*"[2] The academy elaborated on this definition, noting: "In science, explanations must be based on naturally occurring phenomena. Natural causes are, in principle, reproducible and therefore can be checked independently by others. If explanations are based on purported forces that are outside of nature, scientists have no way of either confirming or disproving those explanations."[3] Thus science, properly defined, cannot possibly conflict with religion, since it can say nothing one way or the other about the existence or nature of a supreme being.

It is widely presumed that miracles are contraventions of natural law. But Church authorities have rejected this notion. Brigham Young declared, "Yet I will say with regard to miracles, there is no such thing save to the ignorant—that is, there never was a result wrought out by God or by any of His creatures without there being a cause for it. There may be results, the causes of which we do not see or understand, and what we call miracles are no more than this—they are the results or effects of causes hidden from our understandings."[4] James E. Talmage, who later became an Apostle, was even more explicit: "Miracles are commonly regarded as occurrences in opposition to the laws of nature. Such a conception is plainly erroneous, for the laws of nature are inviolable. However, as human understanding of these laws is at best but imperfect, events strictly in accordance with natural law may appear contrary thereto. The entire constitution of nature is founded on system and order."[5]

In short, scientists and Latter-day Saint authorities reject the fundamental basis for a conflict between science and religion. Nonetheless, many young people and adults alike often ask questions about how science and religion interact. While definitive answers are often not attainable, direct and honest information should be provided whenever possible, and truth should be embraced no matter its source.

Biblical Inerrancy

Many common misunderstandings in the science-religion arena are rooted in the idea of *biblical inerrancy*, the notion that the Bible is an *infallible* and *complete* repository of God's word, so it must be read as a scientific and historical treatise as well as a religious text. Biblical inerrantists typically insist

that Genesis should be read very literally as the creation of the earth (or the entire universe) *in toto* (completely) and *ex nihilo* (out of nothing) over a six-day period, approximately six thousand years ago.

But this view of the Bible goes well beyond the view taught by the leaders of the Church. Indeed, the term *biblical inerrancy*, and the relatively inflexible philosophy it represents, are absent in Latter-day Saint discourse. Joseph Smith, in his history of the First Vision as recorded in the Pearl of Great Price, recalled his great frustration at the numerous contending preachers in his area who all quoted the Bible to advance their particular interpretations.[6] He ultimately concluded that many of the issues he was concerned about could not be resolved solely by literal readings of biblical scripture—additional revelation was needed. In a similar vein, the Book of Mormon, which was published a few years after his first vision, noted that many "plain and precious things" had been deleted through the years from the biblical text.[7]

Joseph Smith's successor Brigham Young was rather explicit in acknowledging that the Bible should not be read as a scientific textbook in matters of the Creation: "As for the Bible account of the creation we may say that the Lord gave it to Moses, or rather Moses obtained the history and traditions of the fathers, and from these picked out what he considered necessary, and that account has been handed down from age to age, and we have got it, no matter whether it is correct or not, and whether the Lord found the earth empty and void, whether he made it out of nothing or out of the rude elements; or whether he made it in six days or in as many millions of years, is and will remain a matter of speculation in the minds of men unless he give revelation on the subject."[8]

President Joseph Fielding Smith, while frequently emphasizing the truth and accuracy of the scriptures, still acknowledged that limits must be placed on highly literal readings:

> Even the most devout and sincere believers in the Bible realize that it is, like most any other book, filled with metaphor, simile, allegory, and parable, which no intelligent person could be compelled to accept in a literal sense. . . .
>
> The Lord has not taken from those who believe in his word the power of reason. He expects every man who takes his "yoke" upon him to have common sense enough to accept a figure of speech in its proper setting, and to understand that the holy scriptures are replete with allegorical stories, faith-building parables, and artistic speech. . . .
>
> Where is there a writing intended to be taken in all its parts literally? Such a writing would be insipid and hence lack natural appeal. To expect a believer in the Bible to strike an attitude of this kind and believe all that is written to be a literal rendition is a stupid

> thought. No person with the natural use of his faculties looks upon the Bible in such a light.[9]

Some may be surprised at these passages, but they all are consistent with the Church's long-standing approach that while the scriptures must be read carefully and taken seriously (more so than taught by some other faiths), the Bible in particular has faults, and the biblical inerrancy doctrines often taught by denominations that contend with science and that presume science and religion to be at war are definitely rejected. With the more flexible Latter-day Saint view of scripture in mind, most issues in the science-religion arena fade into relative insignificance.

While the scriptures in general are devoid of specifics regarding scientific issues, a few biblical passages have some relevance to science. There are a few references to astronomy, including, interestingly enough, mention of specific stars and constellations. Other passages reflect the ancient cosmology, where the sun, moon, and stars revolve around the earth, which is presumed to be immovable.[10] Many have ridiculed the Bible for such passages, but a more honest reading of these passages reveals they always appear in a poetic context, praising God for the wonders of Creation, and were never intended to be read as scientifically precise declarations of literal fact.

Not a single passage of the Bible or any other scripture is written in the precise, quantitative, testable style of a modern scientific research work. So those who read the Bible or other scriptures as scientific textbooks are mistaken. As Apostle James E. Talmage noted, "the beginning chapters of Genesis, and scriptures related thereto, were never intended as a textbook of geology, archaeology, earth-science, or man-science."[11]

Biblical Chronology

Scholars through the centuries, including the medieval Jewish scholar Maimonides and the seventeenth-century mathematician-physicist Isaac Newton have attempted to develop a comprehensive chronology for the Bible. Some success has been obtained for the period from the reign of King David, roughly 1050 BC, to the Babylonian captivity in 586 BC. Dating earlier than this time is quite problematic, due to numerous historical gaps and discrepancies in the biblical record.[12] Partly for this reason, the Bible Chronology in the latest edition of the Bible published by the Church provides no specific dates for events from the Creation to the start of Saul's reign, roughly 1095 BC.[13]

Similarly, there is no solid archaeological evidence relating to the Old Testament before the Merneptah Stele, dated to 1207 BC, which contains the first mention of Israel in ancient archaeology.[14] This certainly does not mean that earlier biblical figures or biblical events are fictitious, as some have argued, but only that there is no solid scientific evidence to confirm

them. After all, science can say nothing one way or the other about specific persons who, like almost all figures in biblical history, were relatively obscure on the world stage during their lifetimes, nor can it say anything one way or the other about events that are presumed to be beyond the realm of what can be studied by scientific experimentation.

In any event, the message for discussions of science and religion is clear: any attempt to specify an exact date for an early event such as the Creation, based solely on the biblical text, is an exercise in futility. Some may be disappointed in this conclusion, but surely the Bible was never intended to be read primarily as a historical treatise any more than a scientific treatise. Questions such as whether Adam lived 6,000; 60,000; or 600,000 years ago or whether the Exodus occurred in the sixteenth century BC or in the thirteenth century BC are relatively unimportant to the grand themes of religion in general and the scriptures in particular, which are identifying the purpose of human existence, obtaining salvation from sin, developing a code of moral conduct, and serving the poor and downtrodden.

According to the Gospel of Matthew, when Jesus was asked whether Jews should pay taxes to Rome, he replied, "Render therefore unto Caesar the things which are Caesar's; and unto God the things that are God's."[15] Similar advice could be helpful in this discussion: Render unto science the things which are scientific and unto religion the things that are religious.

The Age of the Earth

What does science say about the age of the earth? The oldest mineral ever found, a zircon specimen found in the Jack Hills region of Western Australia, has been measured to be 4.4 billion years old.[16] The oldest meteorites, which were formed at roughly the same time as the earth, are 4.56 billion years old, so this figure is generally taken to be the age of the earth.

The various epochs of the earth's existence have similarly been dated by geologists. For example, the Cambrian explosion, when many skeletal organisms arose, has been dated as a period spanning 20 million years, starting 541 million years ago. Similarly, the last of the dinosaurs perished, evidently from a meteoritic impact, 66 million years ago. A listing of the currently understood geologic time scale can be found in any recent geology reference.[17]

The figures mentioned above are all based on measurements of the levels of certain radioactive nuclear isotopes in mineral samples. The phenomenon of radioactivity is well understood through the use of quantum mechanics, so the formulas used in these calculations are on very solid ground. It is also worth noting that when astronomers view a supernova exploding in a distant galaxy, say 100 million light-years away, that explosion actually occurred 100 million years ago. Yet, from all evidence, the processes of radioactive decay and other phenomena seen in these supernovas are indistinguishable

from the results of experiments in earth-based laboratories today. Thus a telescope is a time machine of sorts, permitting scientists to see in considerable detail the laws of physics and radioactivity in operation long ago and to verify that these laws have not significantly changed over the eons.

Like any scientific procedure, radiometric dating measurements are subject to errors and uncertainties. But decades of study have led to a thorough understanding of these pitfalls and specific ways to avoid them. Thus scientists today have considerable confidence in radiometric dating when used in accordance with well-established procedures. Tens of thousands of rigorously peer-reviewed radiometric dating measurements have been published in scientific journals, and thousands more are added each year.[18]

Radiocarbon dating, also known as Carbon-14 dating, is based on the fact that when a plant or animal organism dies, it stops ingesting Carbon-14, and the amount of Carbon-14 gradually decreases, with a half-life of 5,730 years. Because of this relatively short half-life, Carbon-14 measurements are useful for dating artifacts of a relatively recent vintage, as far back as roughly 50,000 years ago. But radiocarbon dating and its potential errors have no bearing one way or the other on the age of the earth or the ages of any of the major geologic eras, since these epochs are all much more ancient than 50,000 years old.

The Church's Position on the Age of the Earth

Some past Church authorities, mostly in the nineteenth and early twentieth centuries, taught that the earth was just a few thousand years old, but others espoused a more expansive view. Brigham Young taught there was no specific revelation on the topic.[19]

Elder Bruce R. McConkie once taught that the Creation lasted 6,000 years,[20] but he later wrote that each day was "an age, an eon, a division of eternity."[21] More recently, Elder Russell M. Nelson declared: "In Genesis and Moses, those periods are called days. But in the Book of Abraham, each period is referred to as a time. Whether termed a day, a time, or an age, each phase was a period between two identifiable events—a division of eternity."[22]

In short, the Church does not officially state the age of the earth, nor by what specific means it was created. As the article "Earth" in the *Encyclopedia of Mormonism* explains, "The scriptures do not say how old the earth is, and the Church has taken no official stand on this question. . . . Nor does the Church consider it to be a central issue for salvation."[23]

Evolution

Merriam-Webster's Collegiate Dictionary lists several definitions for the word "theory," including (a) "a plausible or scientifically acceptable general principle

or body of principles offered to explain phenomena, e.g., the wave theory of light" and (b) "a hypothesis assumed for the sake of argument or investigation; an unproved assumption."[24] In most scientific discourse, scientists use definition (a), while in popular public discourse, definition (b) is more widely assumed. This distinction is the root of the widespread misunderstanding of the phrase "theory of evolution."

Evolution is certainly not a theory in the sense of a sketchy conjecture that has never been seriously tested. On the contrary, evolution has passed more than a full century of rigorous empirical tests covering every aspect. It is termed a theory in the same sense that one refers to *atomic theory* or the *theory of relativity*, namely because it is a general principle with substantial explanatory power and falsifiability that has withstood rigorous scrutiny.

On the other hand, most scientists are content with the double meaning of "theory" as a form of self-imposed humility and resistance against taking any theory as unchangeable truth. The tentative nature of scientific theories was impressed on scientists most vividly in the early twentieth century when Newton's classical laws of motion and gravitation, which had dominated scientific research for more than three centuries, were displaced by Einstein's relativity for objects traveling at very high speeds and by quantum mechanics for very small objects, such as atoms and subatomic particles. Thus, even well-established theories are often modified and refined as more experimental evidence is accumulated. This could be the case with evolution as well.

So what exactly is the theory of evolution? It is the theory that differences between organisms have developed over eons of time because of processes such as mutation and natural selection, ultimately resulting in different species; in particular, species today on earth are descended from common ancestors over millions of years. The principal lines of evidence supporting evolution can be briefly summarized as follows:

1. **Geological evidence:** Various geological eras, as identified by the fossils they contain, nearly always appear in the same order worldwide and yield the same geological dates when measured by radiometric dating techniques.
2. **Fossil evidence:** The partial record of prehistoric species that have populated the earth over eons of geological time is preserved in stone.
3. **Morphological evidence:** Similarities between the physical structure and function of existing biological species are evidence of common ancestry, and the degree of similarity can be used to organize species into a family tree.
4. **DNA evidence:** Direct analyses of DNA sequences or protein chains, analyses that are made possible by the recent dramatic advances in DNA sequencing technology, provide a clearer picture of the interrelationship of species and diversification over time.

Evidence is not always bulletproof, but as scientists have continued to collect more data and develop new technologies, uncertainties have been minimized or eliminated. For example, even today gaps exist in the fossil record. But almost all biological organisms that have ever lived were either eaten by predators or otherwise destroyed soon after death, leaving no trace. Most that persisted in some form, through preserved skeletons, were later destroyed by chemical effects or were part of a geological layer that subsequently disappeared into the earth's molten mantle. Almost all fossils that have survived these and numerous other perils lie far beneath the earth's surface and will never be seen by humans. Consequently, the fossil record will never be complete—all we can expect is to capture glimpses of the earth's flora and fauna over its multi-billion-year history.[25]

Even so, numerous gaps that were once thought to exist in the fossil record have been filled. For example, scientists once despaired of ever finding transitional fossils linking ancient land mammals and marine mammals such as orcas, whales, and dolphins. But within the last two or three decades, at least thirty intermediate fossil species for these groups have been found, with exactly the expected combination of terrestrial and aquatic features.[26] Also, in 2004 researchers discovered the Tiktaalik fossil in a remote area of Ellesmere Island, above the Arctic Circle in Canada. It spans the transition between ancient fish and the earliest four-legged creatures.[27] Many, many other examples could be listed.

In the past few years, modern genome sequencing and computer technology have placed an enormous volume of DNA data only a mouse-click away from researchers worldwide. The first draft of the human genome was completed in 2000 after a ten-year effort that cost hundreds of millions of dollars. Fortunately, now all genomes can be sequenced much more inexpensively—at a cost of roughly one thousand dollars.[28] Among other things, DNA analysis provides a new means, independent of studies of comparative anatomy and other methods used in the past, of quantitatively measuring the evolutionary distance between species and, hence, can be used to convincingly and objectively arrange species in an evolutionary family tree.

For instance, DNA studies have shown that the DNA sequence for human beta globin, a component of blood, is identical to that in chimpanzees and differs in only one amino acid location from that of gorillas, but it is increasingly different from the similar sequence in other animals. Similarly, the gene that when mutated results in cystic fibrosis in humans is nearly identical to the corresponding gene in chimpanzees but is progressively less similar to the corresponding gene in orangutans, baboons, marmosets, lemurs, mice, chickens, and puffer fish.[29]

Another interesting example is the "GULO" gene, which is an essential part of the biochemical machinery that makes Vitamin C in animals. Humans and some primates lack a functioning copy of this gene—it is

mutated; scurvy results when these species don't get enough Vitamin C in their diet. But even though the human GULO gene is mutated and completely useless, humans and chimpanzees have very similar copies of it (98 percent identical). Evidently, a common ancestor of humans and chimps adopted a diet rich in fruits and vegetables. Thus a chance mutation that disabled Vitamin C production was not damaging and was passed on to posterity to both branches of the family tree.[30]

Transposons, or "jumping genes," are mutations where sections of DNA have been copied from one part of an organism's genome and pasted in another. Most of the time, these inserted genes do no damage because they land in relatively unimportant sections of DNA. They do, however, provide an excellent means to classify species into their family tree relationship. This is because it is exceedingly unlikely that the same random insertion of an entire gene would occur at the same spot in the genomes of two or more different species—unless, of course, each inherited this curious feature from a common ancestor.

The diagram below illustrates how transposon data can be used to determine the family tree relationship of various primates. The columns labeled ABCDE denote five known blocks of transposons, and x and o respectively denote that the block is present or absent. It is clear from this data that our closest relatives are bonobos and chimpanzees.[31]

Transposon Blocks

Species	A	B	C	D	E
Human	o	x	x	x	x
Bonobo	x	x	x	x	x
Chimp	x	x	x	x	x
Gorilla	o	o	x	x	x
Orangutan	o	o	o	x	x
Gibbon	o	o	o	o	o

From evidence such as the above, nearly all scientists are convinced that evolution is the best scientific explanation for the observed data. Species have evolved over millions of years, are still evolving, and are descended from common ancestors.

Do Scientists Understand the Origin of Life?

Not all questions can be answered through evolutionary biology. For example, scientists do not yet fully understand the origin of life. In particular, the origin of the first self-reproducing biomolecules, on which evolutionary processes could operate to produce more complicated systems, remains

unknown. However, recent research has yielded tantalizing clues. For example, in December 2014 scientists produced the four bases of RNA, a relative of DNA, in a laboratory experiment simulating the meteorite bombardments of the early earth.[32] But researchers are still far from fully understanding the origin process. Some scientists even speculate that the first living microbes came from outside the earth, possibly on a meteorite from Mars, although this does not solve the origin mystery.

There are also numerous unanswered questions on the path from the origin of life leading up to multicellular organisms. Unlike bony structures that leave fossil records, the early stages of biological evolution on the planet very likely have been completely erased, so we may never know for sure the full details of what transpired.

In addition, some questions remain as to the driving forces for evolutionary change and speciation. The current hypothesis is that the principal forces behind evolution are largely *random* mutations combined with largely *nonrandom* forces of natural selection. But even here, there have been changes in the prevailing theories. For example, the appearance of transposons, mentioned above, has challenged earlier notions that mutations are *local* events in DNA. It is also known that epigenetic effects, namely effects not connected to changes in DNA, can be passed on to posterity. For example, a father's smoking history may affect the health of his sons and grandsons, even though his DNA sequence is not involved and even if no secondhand smoke is involved.[33]

But in any event, questions such as how life started, whether mutations and natural selection suffice to account for evolutionary changes, or whether the pace of natural evolution is sufficiently rapid are all quite irrelevant to the basic issue of whether or not evolution has occurred. The evidence that evolution has occurred and continues to occur is overwhelming and universally accepted by the scientific community.

Is the Biological World "Designed"?

Some have argued that there is design in the natural world that suggests direct, hands-on creation by God. Surely there are many beautiful and wondrous features in the natural world. But as with many issues in the science-religion arena, caution should be taken before embracing this concept.

After all, looking for design in nature is a two-edged sword, since design fails by itself to explain the pain, violence, and suffering apparent in the natural world. For example, scurvy, that scourge of British sailors on the high seas and Mormon pioneers at Winter Quarters, occurs in humans when they do not get enough Vitamin C. Although almost all other mammals generate their own Vitamin C, this machinery doesn't work in humans because mutations have inactivated a key process, as previously noted.[34] Numerous other examples could be cited.

So did God meticulously and deliberately design humans with these specific defects and vulnerabilities, or did he, at a much higher level, create the world and a system of elegant laws that are conducive to the formation of living creatures, including us? And is it not our sacred duty to utilize the scientific method to understand these problems, and, where possible, to counter their effects and mitigate the suffering that results from them?[35] At the least, available evidence suggests that design should be seen in a high-level sense, perhaps even in the laws governing the earth and the universe, rather than in specific, low-level mechanics of individual organs and species.

The Church's Position on Evolution

In 1909, the First Presidency released a statement entitled "The Origin of Man." It included the following passage: "It is held by some that Adam was not the first man upon this earth, and that the original human being was a development from lower orders of the animal creation. These, however, are the theories of men."[36] However, a few months later, an editorial by the First Presidency in the *Improvement Era* addressed the following question: "In just what manner did the mortal bodies of Adam and Eve come into existence on this earth?" The editorial responded: "Whether the mortal bodies of man evolved in natural processes to present perfection, through the direction and power of God; whether the first parents of our generations, Adam and Eve, were transplanted from another sphere, with immortal tabernacles, which became corrupted through sin and the partaking of natural foods, in the process of time; whether they were born here in mortality, as other mortals have been, are questions not fully answered in the revealed word of God."[37]

In 1925, the First Presidency released a statement titled "Mormon View of Evolution." This statement was essentially a shortened and edited version of the 1909 statement. But it did not include the passage discussing whether humans developed from earlier species.[38]

In 1930, Elders Joseph Fielding Smith, Brigham H. Roberts, and James E. Talmage were debating the issue of whether there were humans or other creatures before the Fall of Adam. Elder Smith argued against the possibility of pre-Adamites, or, in a larger sense, of any evolution, a view that he later expanded in his book *Man: His Origin and Destiny*.[39] Elder Roberts countered that we should pay attention to findings of scientific research, a view that he elaborated on in his 1931 manuscript *The Truth, the Way, the Life*: "To limit and insist upon the whole of life and death to this side of Adam's advent to the earth, some six or eight thousand years ago, as proposed by some, is to fly in the face of the facts so indisputably brought to light by the researcher of science in modern times."[40] Elder Talmage's view is indicated by the following statement, from a 1931 talk: "Geologists say that these very simple forms of plant and animal bodies were succeeded by

others more complicated; and in the indestructible record of the rocks they read the story of advancing life from the simple to the more complex, from the single-celled protozoan to the highest animals, from the marine algae to the advanced types of flowering plant—to the apple-tree, the rose, and the oak. . . . What a fascinating story is inscribed upon the stony pages of the earth's crust!"[41]

In 1931, after some period of discussion between these authorities, the First Presidency sent a letter to all Church leaders that concluded: "Upon the fundamental doctrines of the Church we are all agreed. Our mission is to bear the message of the restored gospel to the people of the world. Leave Geology, Biology, Archaeology and Anthropology, no one of which has to do with the salvation of the souls of mankind, to scientific research, while we magnify our calling in the realm of the Church."[42]

In 1992, the Brigham Young University Board of Trustees and the First Presidency approved a packet of materials on "Evolution and the Origin of Man." It includes the 1909 First Presidency statement, a 1910 First Presidency comment, the 1925 statement, and the 1992 *Encyclopedia of Mormonism* article on evolution. The *Encyclopedia of Mormonism* article on evolution, which was prepared under the direction of President Gordon B. Hinckley, includes the passage from the 1931 First Presidency letter previously quoted.

It is quite apparent that in regards to evolution, as with the age of the earth, Church leaders are not interested in engaging in technical debates that are well outside the scope of the Church's central mission. Instead, they have stated that such matters should be left to scientific research.

Along this line, Brigham Young University and BYU–Idaho offer robust areas of study in modern science, including astronomy, botany, zoology, geology, physics, chemistry, computer science, and mathematics. Evolution and old-earth geology, in particular, have been taught at the university for decades with full approval from Church leadership, with several of the BYU and BYU–Idaho faculty making notable contributions to these fields.

Big Bang Cosmology and the "Cosmic Coincidences"

The Big Bang is the name given by scientists for the origin of our visible universe, which has been dated to 13.8 billion years ago. The Big Bang cosmology theory arose in the 1920s, when American astronomer Edwin Hubble showed that the distances to far galaxies were roughly proportional to their outward velocities. This implied that the entire universe is expanding, and there must have been a time when the universe was much denser than it is today. The Big Bang cosmology received additional support in 1964, when two radio astronomers showed that low-level noise in an antenna was the echo of the universe itself from 300,000 years after the Big Bang.[43]

At about the same time, theoretical calculations by researchers concluded that the Big Bang would have produced a universe that is roughly 75 percent hydrogen and 25 percent helium, with traces of other elements, which matches observed figures in impressive detail.[44] More recently, measurements of the cosmic microwave background using satellites, beginning in 1993, show spectacular agreement with the theory.[45] Some questions remain concerning the *inflation* scenario, wherein the universe underwent a spectacular expansion in the first tiny fraction of a second after the Big Bang, but the basic notion that the universe we see originated in an event 13.8 billion years ago is based on solid scientific data.[46]

With regards to physics and the Big Bang cosmology, recent research has revealed some truly intriguing features, often termed the "cosmic coincidences," which suggest our particular universe and its laws seem astonishingly fine-tuned for the rise of intelligent life. For example, if gravitation had been only slightly stronger in the early universe, the expansion would have stopped and even reversed long ago, ending the universe long before any intelligent creatures would have arisen. On the other hand, if gravitation had been ever so slightly weaker, stars and galaxies might not have formed until matter was too dispersed, leaving the universe a cold and lifeless place.

Numerous other coincidences have been noted in scientific literature, for example:

a. **Carbon resonance and the strong force:** The Big Bang theory is remarkably successful in explaining the abundances of hydrogen, helium, and lithium. The synthesis of heavier elements, beginning with carbon, remained a mystery until 1951 when astronomer Fred Hoyle hypothesized and then discovered a nuclear *resonance* that is just energetic enough to permit carbon to form. The energy at which this resonance occurs depends sensitively on the interplay between the strong nuclear force and the weak nuclear force. If the strong force were slightly stronger or slightly weaker (by just 1 percent in either direction), there would be no carbon or any heavier elements anywhere in the universe and thus no carbon-based life forms like us.[47]
b. **The electromagnetic-gravitational strength ratio:** In 1974, Brandon Carter noted that if gravity were slightly stronger, all stars would be radiative rather than convective, and planets might not form. But if gravity were somewhat weaker (so that the ratio was higher), then all stars would be convective and supernovas might not happen. Since all elements on the periodic chart from carbon on up are synthesized in supernova explosions, there would be no carbon-based life.[48]
c. **The proton-to-electron mass ratio:** The ratio of the mass of the neutron to the mass of the proton is approximately 1.0013784. In other words, the neutron's mass is slightly more than the combined

mass of a proton, an electron, and a neutrino. As a result, free neutrons, or those neutrons that are not tied up in the nucleus of an atom, spontaneously decay with a half-life of about ten minutes. If the neutron were slightly less massive, then it could not decay without energy input. If its mass were lower by 1 percent, then isolated protons would decay instead of neutrons, and very few atoms heavier than lithium could form.[49]

d. **The cosmological constant:** This paradox derives from the fact that when one calculates, based on known principles of quantum mechanics, the "vacuum energy density" of the universe, focusing on the electromagnetic force, one obtains the absurd result that empty space should "weigh" 10^{93} grams per cc, whereas the actual average mass density of the universe is 10^{-28} grams per cc. This is a discrepancy factor of 10^{120}, which is the number 1 followed by 120 zeroes![50] Physicists who have fretted over this huge discrepancy for decades have noted that calculations such as the above involve only the electromagnetic force, so perhaps when the contributions of the other known forces are included, all terms will cancel out to exactly zero as a consequence of some currently unknown principle of physics.

These hopes were shattered with the 1998 discovery that the expansion of the universe is accelerating, which implies that the cosmological constant, which is tied to the vacuum energy density through Einstein's general relativity, must be slightly positive. But this means that physicists are left to explain the startling fact that the positive and negative contributions to the cosmological constant cancel to 120-digit accuracy yet fail to cancel beginning at the 121st digit. Curiously, this observation is in accord with a prediction made by physicist Steven Weinberg in 1987, who argued from basic principles that the cosmological constant must be zero to within one part in roughly 10^{120}. If not, the universe either would have dispersed too fast for stars and galaxies to have formed or else would have recollapsed long ago.[51]

In short, numerous features of our universe seem fine-tuned, often astoundingly so, for the existence of intelligent life. As British astronomer Fred Hoyle said, "A commonsense interpretation of the facts suggests that a super-intellect has monkeyed with physics, as well as the chemistry and biology, and that there are no blind forces worth speaking about in nature. The numbers one calculates from the facts seem to me so overwhelming as to put this conclusion almost beyond question."[52]

Some scientists have invoked the "anthropic principle" to explain such phenomena. In other words, they postulate that our universe is merely one of an enormous (possibly infinite) multitude of universes, and the reason we find ourselves in a universe with such an extremely fine-tuned set of

parameters conducive to intelligent life is that if our universe were not like this, we would not be here to ask the question. But other researchers find such "anthropic" reasoning most unsatisfying.[53]

God of the Gaps

Many argue that apparent design in the biological world or the cosmic coincidences of the universe constitute *proof* that our universe was designed by a supreme being. But caution is in order since experience has taught us that claims that one can prove God based on inexplicable phenomena in the natural world often disappoint in the long run. Such reasoning even has a name: the "God of the Gaps" approach to science and religion. It has, in most cases, left a legacy of disappointment as science advances.

To begin with, there is no fundamental reason, scientific or theological, why God should only be found in the gaps of scientific knowledge. To the contrary, as noted biologist and author Kenneth Miller, a Roman Catholic, observed: "[God of the gaps proponents] inevitably look for God in what science has not explained or in what they claim science cannot explain. Most scientists who are religious look for God in what science does understand and has explained."[54]

Furthermore, invoking a Creator or a Designer every time unexplained phenomena arise is a "thinking stopper," burying the grand questions of science and religion in the inaccessible mind of God while lessening our motivation to discover the principles underlying these phenomena on our own. So while the earth and the universe are indeed magnificent beyond description, let's not think that we can *prove* God with technical reasoning. Faith is still necessary.

Embracing Science and Religion in One's Quest for Truth

This is an exciting time to be alive. The fields of science and technology are surging ahead with remarkable discoveries on many fronts: artificial intelligence, DNA sequencing, biomedical technology, commercial space travel, discovery of numerous planets orbiting other stars in the habitable zone, and a never-ending stream of amazing advances in computer technology. President Gordon B. Hinckley summarized these developments when he declared:

> But in a larger sense [the twentieth century] has been the best of all centuries. In the long history of the earth there has been nothing like it. The life expectancy of man has been extended by more than 25 years. Think of it. It is a miracle. The fruits of science have been manifest everywhere. By and large, we live longer, we live better. This

> is an age of greater understanding and knowledge. We live in a world of great diversity. As we learn more of one another, our appreciation grows. This has been an age of enlightenment. The miracles of modern medicine, of travel, of communication are almost beyond belief. All of this has opened new opportunities for us which we must grasp and use for the advancement of the Lord's work.[55]

What's more, it is inarguably true that everyone, of both scientific and religious backgrounds, can stand in awe at the majesty of the universe. Albert Einstein understood this principle well, even though he personally had difficulties with traditional notions of God. He once wrote: "On the other hand, I maintain that the cosmic religious feeling is the strongest and noblest motive for scientific research. . . . Those whose acquaintance with scientific research is derived chiefly from its practical results easily develop a completely false notion of the mentality of the men who, surrounded by a skeptical world, have shown the way to kindred spirits scattered wide through the world and through the centuries. Only one who has devoted his life to similar ends can have a vivid realization of what has inspired these men and given them the strength to remain true to their purpose in spite of countless failures. It is cosmic religious feeling that gives a man such strength."[56]

But while discussions of evolution, astronomy, physics, and cosmology may be engaging and even inspiring, it is not clear that they relate in a substantive way to what most religious people experience. Was Mother Teresa inspired by the "cosmic coincidences" to devote her life to India's poor? Did Johann Sebastian Bach have the "God of the Big Bang" in mind when he composed over a thousand pieces of sacred music? Are millions of contemporary persons, of Latter-day Saint and other religious traditions, inspired by discovery of the Higgs boson when they devote their lives to religious service? Probably not. As Holmes Rolston observed, "The religion that is married to science today will be a widow tomorrow. . . . Religion that has too thoroughly accommodated to any science will soon be obsolete."[57]

So in the end, religious beliefs cannot be either proven or disproven by science. Individuals are still more likely to find God on their knees, in the soup kitchen, and in living a righteous, productive, and charitable life than in the scientific laboratory.

Additional Resources

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See other articles on science and religion by D. H. Bailey at http://www.sciencemeetsreligion.org.

About the Author

David H. Bailey is a mathematician/computer scientist, recently retired from Lawrence Berkeley National Laboratory and is also affiliated with the University of California, Davis. He is the author of six books and over two hundred technical articles in the area of high-performance scientific computing, computational mathematics, mathematical finance, and computational biology. He has received the Sidney Fernbach Award from the IEEE Computer Society, the Gordon Bell Prize from the Association for Computing Machinery, and the Chauvenet Prize and Merten Hesse Prize from the Mathematical Association of America. In addition, he operates the website Science Meets Religion, with over eighty articles on science and religion and a blog. He and his wife, Linda, live in Alamo, California. They are the parents of four children and have seven grandchildren. They serve in the Alamo First Ward of the Danville California Stake.

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