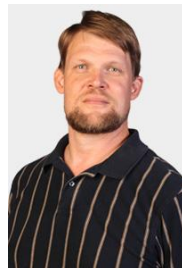




***What I Wish My Pastor Knew About ...***  
**the Universe and Multiverse**



<http://ministrytheorem.calvinseminary.edu>



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### **Called to Christ and to Science**

By the time I was ten years old, I was already determined to follow a career in physics and cosmology, both because of the wonder I felt for the natural world and as a means to better resolve serious questions that were already developing within me regarding the relationship between biblical interpretation and scientific discovery. The prior year I had read and studied scripture in its entirety for the first time, rather than just the piece-meal sections covered in my Sunday School classes. Whenever I look back at that year in my life, I am always glad I chose to study first the New Testament wholly before proceeding back to the Old Testament, rather than vice-verse. From the New Testament study I found salvation and accepted Christ into my life. But my examination of the Old Testament that followed raised serious questions for me regarding the biblical portrayal of God, His nature, and His methods. The study of Genesis was a focal point of this. The questions about the Old Testament that arose within me were so severe, that if I had studied the Old Testament first, the development of my faith and personal theology would have been seriously affected for several years, in the least.

The Old Testament concerned me for two reasons: (1) the apparent conflict between Genesis and what I had already learned about the history of the universe, of earth, and of life on earth as reported by science and (2) the savageness portrayed throughout the Old Testament. (While these issues might seem a bit much for a ten-year-old to be concerned about, it was in the context of a ten-year-old with high school reading ability/comprehension and a 163 IQ.) The focus of this essay is on the first issue. Discussion of the second issue remains for another time.

With regard to the apparent conflict between the Genesis creation accounts and science, the scientific version of creation made much more sense to me, especially if Genesis 1 and 2 were to be taken literally. From science I felt an amazement and a wonder towards God as Creator and strongly desired to learn more about the physical laws set up by God that sustained the

universe. In contrast, both of the Genesis stories of creation seemed simplistic and hollow, in particular the descriptions of both the creation of the universe and the earth, and of the creation and fall of humankind. Even to me then, the latter seemed on par with the Greek myths. Further, from Genesis 2:4 forward, the characters, including God, appeared naïve and two-dimensional. The portrayal of God in Genesis seemed both primitive and finite. God did not appear to be omniscient, omnipresent, or omnipotent—in contradistinction to the rendering of God in the New Testament. Rather, the Old Testament seemed to describe God with similar traits to a human of that era, except with significantly more power.

I spent quite a while that year seeking a resolution to my concerns about the Genesis portrayal of God. If I had not already developed an understanding of the nature of God from the New Testament, I would have rejected belief in scripture as anything inspired of God for several years and not come to salvation until a much later age, if at all. Instead, I reached the only possible conclusion that made sense: that divine inspiration of scripture does not exempt scripture from portraying human authors' limited (in particular, finite) understandings of God and of the physical world. This was in line with the concept of progressive revelation.

For the Old Testament writings, this meant an initially very limited, but developing, understanding of God and the nature of God. Further, and especially important for reading and interpreting Genesis 1 and 2, a non-scientific description of the creation process is what should be expected from a pre-scientific age. Divine inspiration allowed the language of the day to express eternal truths regarding some aspects of God's nature as Creator. Genesis 1 and 2 must be taken as "true myth" cosmogonies rather than as scientific cosmologies. Using stock images of the day, they describe God as the ultimate Creator of all things and in charge of all things. These chapters should not be mis-interpreted as scientific treatises describing the actual physics

processes by which God creates all things. (While this is not the exact diction by which I expressed my conclusions 36 years ago, it does indeed convey the content of the beliefs I formed then and have continued to embrace ever since.)

From further study I came to understand that for almost 2000 years many others far more knowledgeable than I had wrestled with these issues. I was thrilled to learn that the early church fathers had developed a procedure for dealing with disagreement between scripture and scientific understanding. Back in 1657, the famous scientist/mathematician and devote Christian, Blaise Pascal, summarized the procedure of St. Augustine and Thomas Aquinas in his writings:

When we meet with a passage even in the Scripture, the literal meaning of which, at first sight, appears contrary to what the senses or reason are certainly persuaded of, we must not attempt to reject their testimony in this case, and yield them up to the authority of that apparent sense of the Scripture, but we must interpret the Scripture, and seek out therein another sense agreeable to that sensible truth ... And as Scripture may be interpreted in different ways, whereas the testimony of the senses is uniform, we must in these matters adopt as the true interpretation of Scripture that view which corresponds with the faithful report of the senses. ...

An opposite mode of treatment, so far from procuring respect to the Scripture, would only expose it to the contempt of infidels; because, as St. Augustine says, "when they found that we believed, on the authority of Scripture, in things which they assuredly knew to be false, they would laugh at our credulity with regard to its more recondite truths, such as the resurrection of the dead and eternal life." "And by this means," adds St. Thomas, "we would render our religion contemptible in their eyes, and shut up its entrance into their minds."

During my teenage years, my conviction that science could be used to inform scripture and clarify our understanding and interpretation of it continued to develop. I agreed with Galileo that "the Bible tells us how to go to heaven, not how the heavens go." Further, since God is the Creator of all things, the physical and the spiritual, I came to understand that science as the study of the physical and theology as the study of the spiritual must be mutually consistent when both are properly understood. Inconsistency could only be the result of human misunderstanding of one or both arenas of knowledge.

(Some might correctly point out that science is not always so clear-cut as reason plus the report of the senses. That is, at times science also involves debates between competing interpretations, especially on the cutting edge of research. Nevertheless, ongoing scientific investigations gradually winnow away many or most proposed scientific descriptions of a given physical process, leaving only one or a few as the viable candidates. Scientific theories are formed by the general consensus of the scientific community based on overwhelming supporting physical evidence.)

While in high school, I belonged to a student-led interdenominational bible study group. Whenever we discussed Genesis, it became clear that the majority of the students held to a literal interpretation of Genesis 1 & 2 as a fundamental tenet of Christian faith. Most members were young earth creationists. I had not encountered such strong claims prior to that group. For a short time I began to re-examine my understanding of Genesis and considered the other students' claims that the evidence amassed from many independent fields of science had all been misinterpreted by scientists. My conclusion, however, was that the accumulated scientific data did conclusively support a 10 to 15 billion year universe (the age had not yet been pinned down more) and an evolutionary history of life on earth and therefore that the proper interpretation of Genesis 1 and 2 was still as true myth or metaphor and not as scientific statement. But my association with the bible study group helped me to understand the mindset of the "literalists" and young earth

creationists.

During my junior and senior high school years I was also facing a medical problem that came close to taking my life more than once—and that was incorrectly diagnosed as epilepsy for several years. During my senior year in high school the true cause of my health problem was discovered—a brain tumor. A week after giving the valedictorian address to my graduating class, on the theme of trusting God as we each chose a path onward for our lives, I had brain surgery to remove the tumor. Following an unexpected positive change in the tumor (an encapsulation), the surgery was successful. In thankful response to God, I decided to follow a career in church ministry.

I determined a primary goal of my ministry would be to help the members of my future congregation develop mutually consistent and mutually supportive understandings of scripture and of science. I chose to attend Valparaiso University in Indiana, where I could, in addition to being a pre-seminary student and Christ College Scholar, also double major in physics and mathematics to increase my scientific knowledge. Over the course of my four years at Valparaiso, I came to realize that my calling wasn't for a church ministry, but to minister to Christians as a professional scientist, demonstrating by example that faith and science need not be at odds.

Thus, after briefly following somewhat of a curved path, I did indeed follow the vocation I had initially chosen twelve years earlier. I decided once again to pursue the path that made my “heart sing”—studying the underlying laws and forces of the physical universe. As I was deciding which Ph.D. programs in elementary particle physics and cosmology to apply to, I became aware of a new, quickly developing subfield of particle physics called *string theory* that offered the possibility of unifying all of the known forces and matter in the universe into a single theory. John H. Schwarz at Caltech in Pasadena and Michael Green at Queen Mary College in London had just published a paper that proved the consistency of string theory in 10 spacetime dimensions.

I applied to and was accepted at Caltech in 1986 and soon began studying under John Schwarz as my dissertation advisor. In 1993 I received my Ph.D. in string theory and early universe cosmology. Since then I've written over 60 peer-reviewed journal publications and conference proceedings in string theory and string cosmology. My work in this field has been cited over 1300 times. After three postdoc positions I accepted a faculty position at Baylor University in Waco, Texas.

Such has been the path of one particular Christian in the sciences. While each of our lives is unique, I know from conversations with numerous Christian colleagues that many general aspects of my journeys in the realms of science and theology and their overlaps and interconnections are not unique. Several others have faced similar quandaries regarding apparent conflicts between scripture and science. Likely there are some in your congregation. In line with Augustine, Aquinas, and Pascal, I would urge you to not reject their science/theology understandings as non-scriptural should you disagree with them. Rather, invite them to present their knowledge and understanding of the physical creation to the rest of your congregation.

### **Science and Faith Ministry**

Along the way of my journey, I've been presenting lectures on the consistency of faith and science at numerous churches of various denominations. My position at Baylor is within both the physics department and its Honors College, for which I designed and co-teach a senior capstone course on theology and science entitled *Scripture, Cosmology and Creation*. I've also developed and coordinated several science and theology conferences and workshops, e.g., the ELCA 2007 Summer Theological Institute, *Faith & Faithfulness: Christianity in the Age of Scientific Discovery* and the Wheaton University 2008 Science Symposium *String Theory & the Multiverse: Philosophical and Theological Implications*. The director of Baylor's Center for Ministry Enhancement, two Baylor Religion

professors, and I have also created a two day seminar for church pastors on faith-science issues.

The purpose of these courses and programs is to encourage people to develop a consistent Christian *Weltanschauung* wherein scientific and theological understandings of the world and of the universe as a whole are viewed as mutually supportive and complimentary, mutually informing and edifying. The historic “two books” view of nature and scripture is emphasized: the physical world as God’s book of general revelation to us, scripture as God’s book of special revelation.

The relationship between faith and science is, indeed, a very relevant topic today for personal theologies. How one views this relationship can significantly influence career decisions, as students in my Honors College course have demonstrated. The interplay between faith and science has become a major issue within the church community. Programs and articles on related issues frequently appear in the Christian media. Those attending our programs explore aspects of the interplay of faith and science through a study of the three topics most frequently associated with this arena: scripture, the history of the universe as a whole, and the history of life on earth.

### **Advice for Pastors**

I believe the need for these programs is tremendous. In the 36 years since my initial encounter with Old Testament issues, more often than not, within the church I have encountered on one hand either a general fear of science and scientific discovery due to its apparent conflict with scripture or, on the other hand, a desire to better understand both modern science and scripture and their interplay, but little opportunity to do so.

One problem I often see in churches across the United States today is an emphasis on knowing scripture, and much less importance placed on truly understanding it. This lack of scriptural understanding creates a situation that too often

places science and scripture in a false dichotomy. St. Augustine’s and Thomas Aquinas’ process for dealing with these conflicts often seems either unknown, or in the least, forgotten.

I believe that Christians are hungering for much deeper studies of scripture, ones that deal, for example with the Genesis issues I’ve mentioned. However, such studies are often not that common. Thus, I would implore you to lead your congregation into a deeper comprehension not just of scripture, but of the meaning to scripture. Maturing in the faith requires much more than memorizing scripture and the ability to quote it. Don’t allow church members to avoid facing controversial aspects of scripture. Help them to better understand the historical aspects and cultural milieu to the writing of scripture. Assist them in realizing how science can inform faith. Guide them into the resolution process of Augustine and Aquinas.

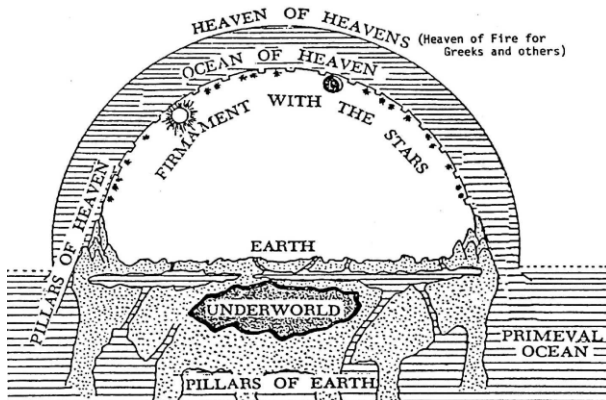
As congregations develop a deeper comprehension of scripture, I would urge you to demonstrate to the members of your congregation how learning about science and scientific discovery can deepen their understandings of scripture, of God’s creative nature, and of the creation. Science can shed new light on theological issues. It can instill in a new manner an awe and reverence for God. In particular, I would like congregations to better comprehend the beauty, order, and wonder displayed in creation through the ongoing discoveries in elementary particle physics and cosmology. But before proceeding with discussion of that, I’d like to take a step back to present a brief overview of the history of the human perception of creation.

### **Expanding Views of the Universe**

Over the last few thousand years the human perception of physical reality has been transformed through a few discrete steps. Each paradigm advancement has presented a larger, grander creation—for Christians each advance should signify a fuller representation of God’s eternal power. As I hope to show, the current stage of scientific discovery may, in fact, denote the

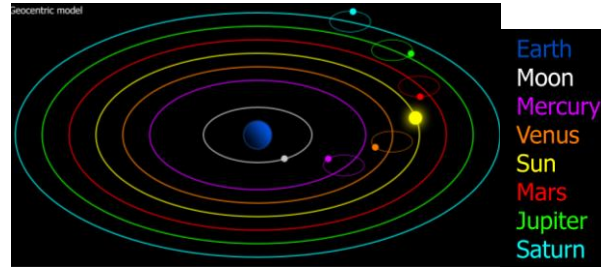
commencement of another profound progression in humankind’s perception of the whole of physical existence and, thus, of the creative nature of God. This new paradigm shift may be of far greater magnitude and vastly more comprehensive than all those preceding.

The Mideastern world of one to two millennia B.C. perceived reality essentially as a 3-tiered structure. Center stage was the flat surface of the earth and the ground below containing the underworld of the dead, e.g., the Sheol of the Old Testament. Beneath this was a primeval ocean upon which the earth floated and into which the pillars of the earth descended. Far above were the split levels of the heavens—the firmament of the stars and the sun and moon; the watery expanse of the heavens kept separated above by a cover (as in Genesis 1:7); often beyond that was the heaven of heavens. This was the setting in which Genesis I was written.



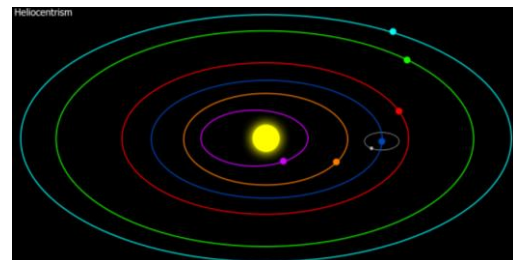
**Three Story Paradigm of the Ancient Mideast World.** (from [GodAndScience.org](http://GodAndScience.org))

The Greek civilization brought about a significant paradigm shift, one that lasted almost one and a half millennia—the *geocentric* picture, in which both the sun and the other planets were believed to orbit about the earth.



**Geocentric Paradigm of Greco-Roman era to 1600’s.** (from [Wikipedia Commons](https://commons.wikimedia.org/wiki/File:Geocentric_model))

Then in the 1600’s, astronomical discoveries by scientists such as Galileo wrought about the realization that the earth and all of the rest of the planets orbited the sun. Thus was born the *heliocentric* era. Simultaneously, the law of gravity was developed by Isaac Newton and proven to apply both on the earth and throughout the whole heliocentric system.



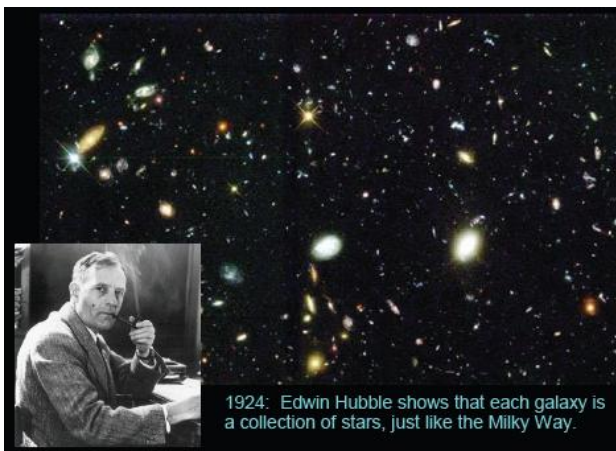
**Heliocentric Paradigm of 1600’s through 1700’s** (from [Wikipedia Commons](https://commons.wikimedia.org/wiki/File:Heliocentrism))

By the 1800’s, astronomers discovered the existence of gaseous nebula beyond the solar system and found that our sun was but one of numerous stars within the so-named Milky Way galaxy. Thus, a *galactocentric* perception replaced the heliocentric. Our galaxy and its contents were believed to compose the entirety of the universe. This was perception of physical reality held by Einstein when he derived his special theory of relativity in 1905.

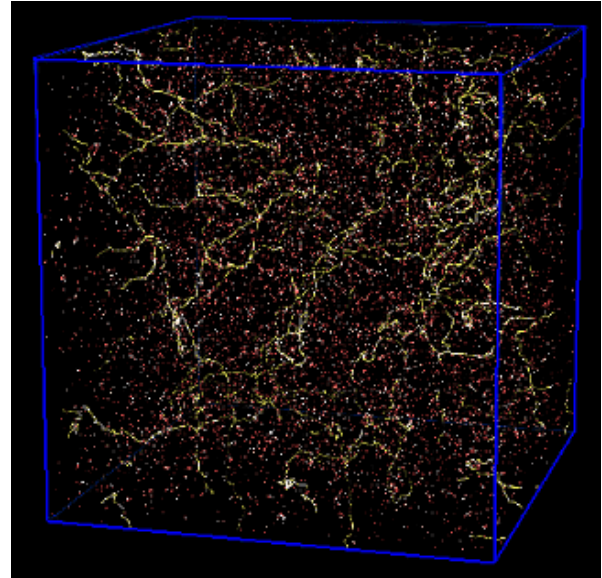


**Galactocentric Paradigm of 1800's through early 1900's.** (from The [Hubble Heritage Team](#), [AURA/STScI/NASA](#))

By the 1920's, many of the objects identified during the preceding century as "spiral nebulae" inside our Milky Way galaxy were realized by astronomers such as Edwin Hubble to actually be independent galaxies, located vast distances (millions to billions of light years) away from the Milky Way and of comparable size to it. Thus, after little more than a century the galactocentric paradigm was transformed into a *univercentric* paradigm, with our universe comprising the entire stage. Over the following decades around a trillion visible galaxies were identified in our universe, each possessing hundreds of thousands to trillions of stars.



**Univercentric Paradigm of 1920's through early 2000's?** (from [Sean Carroll](#))



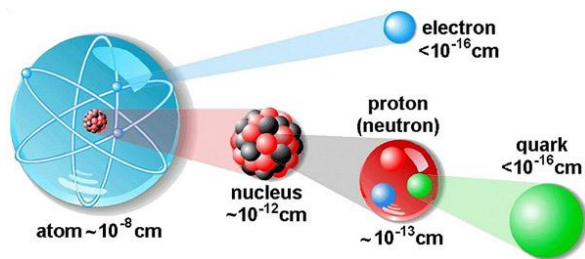
**Computer Generated 3-Dimensional Picture of Visible Universe.** *Each dot is an entire galaxy containing around a several hundred billion to a trillion stars.* (from Cambridge Cosmology Group)

I've presented a very condensed synopsis of the scientific understanding of the universe and our location in it. I believe this basic outline is critical for most Christians to know. Scientific knowledge provides an actual cosmology to accompany the cosmogony of Genesis 1. Put another way, study of God's book of nature has yielded a physical description of the creation process to complement the theological description in God's book of scripture. Scientifically knowledgeable Christians can present a credible faith witness to the world. Thus, a prayer of mine is that many congregations will have the opportunity to learn about this cosmological history of our universe and the paradigms or steps humankind has passed through it its perception of that universe.



the 1950's. Then in the 1960's, a way to combine electromagnetism with the weak nuclear force was discovered and referred to as *electroweak theory*. Simultaneously, understanding of the strong nuclear force was accomplished during 1963 to 1965. The related theory was named *quantum chromodynamics* (QCD). These theories showed that all the fundamental forces (with the exception of gravity) were related.

As the understanding of forces developed, physicists were also learning about particles. Around 1870, the periodic table of elements was developed by Mendeleev and others as a systematic way to organize the dozens of known atoms; today 117 types of atoms are known. In the early 1900s, physicists discovered that each atom is not a solid "billiard ball", but is made of more fundamental particles: protons and neutrons in a nucleus with electrons swirling around the nucleus.



**The particles inside an atom.** (from [ETH Institute for Particle Physics](#))

Yet these particles are still not the most fundamental; high-speed collisions in particle accelerators hinted at the existence of even more fundamental particles. Experiments also began to reveal many particles besides protons, neutrons, and electrons. For a time, physicists were discovering new types of particles faster than they could explain them – there seemed to be a “zoo” of particles rather than orderly categories.

Gradually a more orderly picture came together. Protons and neutrons are indeed made of more fundamental particles, called “quarks,” with each proton made of three quarks. The two most

common types of quarks are called “up” and “down”, and each comes in three flavors (called “red”, “green”, and “blue”). When you add in the electron and the electron neutrino, you get a family of 8 particles (left column of figure on next page). All the atoms in the periodic table can be explained with just those 8 particles. That’s a lot simpler than 117!

Physicists also found that each of these 8 particles has an “anti particle.” Anti-matter is commonly referred to in science fiction (such as *Star Trek*) making it sound very exotic. Yet its only difference from regular matter is the electric charge. If the matter particle is positively charged, its anti-matter partner is identical except with negative charge (or vice-versa). That doubles the number of fundamental particles, making a family of 16 mass particles.

As all of the fundamental matter particles were discovered, physicists were also learning more about forces, and discovered the existence of another category of particle: a “force-carrying” particle. This is difficult to picture, but you have probably already heard of one such particle already, the photon. The photon is the force-carrying particle for the forces of electricity and magnetism, which are closely linked to light. The QCD force is associated with 8 force-carrying particles (called *gluons*, because like a glue, they cause quarks to stick together) and the electroweak force with 4 force-carrying particles, making a set of 12 force-carrying particles (see right column of figure on right).

This picture of forces and particles became known as the *Standard Model* of Elementary Particle Physics. It includes the 12 electroweak and QCD force-carrying particles and the 16 particles making up ordinary matter. It also includes two more exotic families of matter particles with 16 each (for another 32, the middle two columns of figure on right), which explain the remaining particles in the “zoo”. Each particle in an exotic family is nearly identical to a corresponding one of the 16 more familiar ordinary matter particles. The primary difference is that the exotic particles are heavier (more massive).

Two additional particles (the Higgs—named after the physicist who first theorized their existence) believed to exist are also included in the Standard Model. The Higgs are believed to be responsible for making all matter particles massive (verses massless). They are expected to be produced either at Fermilab in Batavia, Illinois, or at the Large Hadron Collider (LHC) at CERN, Switzerland, within the next few years. In total, the Standard Model contains  $62 = 12+16+32+2$  basic particles.

Mathematical aspects of the Standard Model further suggest that each of these 62 particles has associated with it another particle, called its supersymmetric partner. While none of these supersymmetric particles have been found to date at either Fermilab or CERN, if they exist they should also be discovered within the next few years. Their existence would increase the number of basic particles to 124. This set of 124 particles is called the *Minimal Supersymmetric Standard Model*.

Three Generations of Matter (Fermions)				
	I	II	III	
mass→	2.4 MeV	1.27 GeV	171.2 GeV	0
charge→	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	0
spin→	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1
name→	<b>u</b> up	<b>c</b> charm	<b>t</b> top	<b><math>\gamma</math></b> photon
	4.8 MeV	104 MeV	4.2 GeV	0
	$-\frac{1}{3}$	$-\frac{1}{3}$	$-\frac{1}{3}$	0
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1
Quarks	<b>d</b> down	<b>s</b> strange	<b>b</b> bottom	<b>g</b> gluon
	<2.2 eV	<0.17 MeV	<15.5 MeV	91.2 GeV
	0	0	0	0
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1
	<b><math>\nu_e</math></b> electron neutrino	<b><math>\nu_\mu</math></b> muon neutrino	<b><math>\nu_\tau</math></b> tau neutrino	<b>Z<sup>0</sup></b> weak force
	0.511 MeV	105.7 MeV	1.777 GeV	80.4 GeV
	-1	-1	-1	$\pm 1$
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1
Leptons	<b>e</b> electron	<b><math>\mu</math></b> muon	<b><math>\tau</math></b> tau	<b>W<sup>±</sup></b> weak force
				<b>Bosons (Forces)</b>

**Three Generations of Matter Particles and the Force Carrying Particles.** *The left three columns show three families (“generations”) of matter particles (quarks and leptons, shaded purple and green). The right columns shows force carrying particles (bosons, shaded pink). In addition to the particles shown, each quark comes in three so-called colors (red, green, blue), and each of those has an antiparticle with opposite color (anti-red, anti-green, or anti-blue) and opposite electric charge. Each lepton also has an anti-particle of opposite electric charge. Thus, there are  $16 = 2*3 + 2*3 + 2 + 2$  matter particles in each generation. The force carrying particles also come in more varieties than shown (a total of 12). (from [Wikipedia](#))*

### Problems with the Standard Model

Beginning in the 1980's, some elementary particle physicists suggested that the Standard Model might not be the underlying fundamental theory. First, a theory with either 62 or 124 basic particles doesn't seem that simple or fundamental, even if it is more orderly than the earlier "zoo". Next, others asked why, in particular, are there two exotic copies of the everyday set of 16? Further, there is no explanation why the strong force or the electroweak force took the respective form that each did. Lastly, there seemed to be no connection between these forces and the remaining one—gravity.

In the first 80 years of the 20<sup>th</sup> century, physicists went from knowing very little about the universe and its forces to knowing most of its basic features. However, physics in the early 1980's still had a problem parallel to what I have seen within churches and have already discussed. That is, there is a significant difference between knowing and understanding. As with scripture for many churches, the basic features of the universe and its forces were *known*, but much was not *understood*.

### String Theory: One Particle and Ten Dimensions

A possible resolution to the Standard Model issues first appeared in the mid 1980's, called *string theory*. It is a theory that unifies the strong and electroweak forces of the Standard Model, while it simultaneously *reduces* the number of basic particles from 124 to 1. This would be an amazing accomplishment—it would finally achieve the "holy grail" of physics, to unify all the forces into a single picture (sometimes nicknamed the "Theory of Everything", but better called the "Theory of Everything Physical"). It would also simplify the understanding of particles by showing that all particles are fundamentally the same.

According to string theory, there is only one fundamental particle from which both force carrying and matter particles are formed. This particle is essentially a *closed string of energy*.



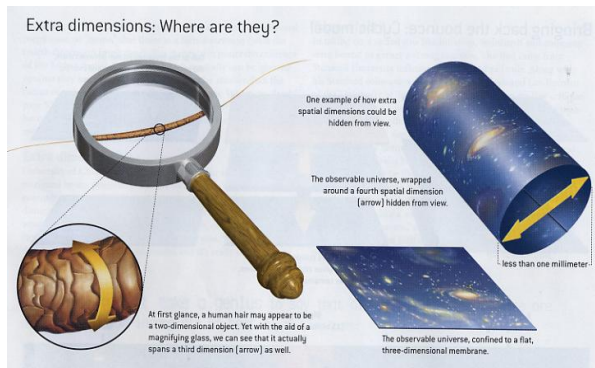
**Fundamental string of energy.** (from [The Official String Theory Web Site](#))

The string is tiny, of length  $10^{-33}$  cm (recall this length was discussed prior—the universe started out no larger than this size). The string of energy can produce all the other particles by vibrating in different ways. Just as vibrations travel up and down on a violin string, so vibrations travel around the energy string. A violinist changes the way the violin string vibrates in order to produce a different musical note. In a similar way, when the energy string changes to a different vibration, it appears as a different type of *particle*. There are many ways the energy string can vibrate, including all sorts of combinations of clockwise and counter-clockwise vibrations, in fact enough different vibrations to explain all of the particles in the standard model.

Thus, string theory solves several difficulties of the Standard Model. But it does much more. It has opened new vistas in our understanding of nature, including multiple universes (discussed below) and whole new dimensions of space in our universe.

Our everyday lives exist in 3 spatial dimensions (height, length, breadth) and 1 time dimension. We can speak of these together as "spacetime" and say that we live in 3+1 spacetime dimensions. In order for string theory to be mathematically consistent, however, spacetime instead must be exactly 9+1 dimensional. That is, 6 additional spatial directions beyond height, width, and depth must exist! Since we can only see (detect) the spatial dimensions of height, width, and depth, scientists immediately realized that these extra dimensions must be very small (referred to as "compact"). Not only are the extra dimensions much too small to see, they are much smaller than an atom. In fact they are of the same length scale as the string itself, that is, around  $10^{-33}$  cm. These

compact dimensions differ in another way from the 3 large dimensions we are used to: they are “closed.” This means that in moving along a compact direction, you would return to the starting point after traversing a distance of only  $10^{-33}$  cm. Picture an ant crawling on an infinitely long garden hose – if it crawls along the length of the hose it can go forever (like one of the 3 large dimensions), but if it crawls around the circumference of the hose it will quickly come back to where it started (like one of the 6 compact dimensions).

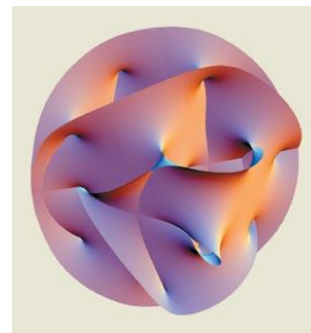


**Example of a Compact Dimension.** (from Astronomy Magazine, Special Cosmology Issue: Origin & Fate of the Universe, 2004)

Astonishingly, the existence of these compact directions is the reason that all forces and matter are related. In fact, in string theory, without compact directions, the number of particles would be vastly reduced to only particles that carry the gravitational force. That’s because such particles involve only vibrations in the spatial directions of height, width, or depth. The force-carrying particles for the other forces (electroweak and strong) are produced when some of the vibration is in the compact spatial dimensions. As for matter particles, these are produced when the energy string vibrates *only* in the compact dimensions. According to string theory, without these extra spatial dimensions, the matter particles making up our bodies could not exist. This is a stunning conclusion: although our bodies exist in the three large dimensions, each fundamental particle in our bodies is a tiny energy string

vibrating in extra compact dimensions of space!

In addition to automatically producing all the forces and all the matter particles, string theory also explains why the particles are the way they are. On a violin, the length of the string and the shape of the sound board determine what vibrations are possible and thus what musical notes can be played. In string theory, the size and shape of the six compact dimensions determines what vibrations the energy string can make and thus what particles are produced. Thus, *the shape of space itself* determines the types of matter particles allowed and (through the force-carrying particles) the strengths and types of the non-gravitational forces. Much of the work of string theory involves figuring out how the 6 compact dimensions might be shaped. It turns out there are 100 trillion possible shapes, each very complicated, called *Calabi-Yau manifolds*.



**Example of a Calabi-Yau manifold.** *This is the likely shape of the compact dimensions. Only 2 dimensions are shown, rather than all 6.* (from [Berkeley Center for Cosmological Physics](#))

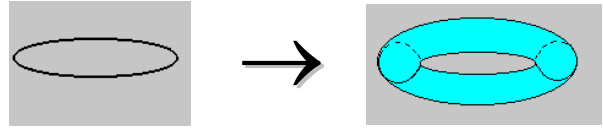
A primary effort of string theorists was to determine which of the 100 trillion possible compact shapes of the extra six compact directions corresponded to the space of our universe. If the correct compact shape could be found, string theory had the potential to be the actual Theory of Everything (Physical). A handful of Calabi-Yau shapes for the six compact dimensions were eventually found that came very close to producing exactly the forces and matter particles of this universe.

This search continued full scale for roughly a decade, with significant progress made in some cases. (In particular in 1999, a colleague and I at Texas A&M, along with a colleague at Oxford, were the first to find a shape for the compact directions that yielded exactly the known force and matter particles—although the theoretical masses of the matter particles did not quite agree with experiment.)

### Eleven Dimensions and Multiple Universes

However, an underlying bothersome issue of string theory was that it wasn't actually a single theory, but five alternative theories. (The model my colleagues and I developed was constructed from one of these five theories.) In each theory, the energy string appeared to possess slightly different properties. Was one theory better than the other four? No one could determine the answer to this, so string theorists were investigating all five theories. That is, until 1994 when a group of string theorists proved that all five string theories were the same thing, with equivalent physics expressed by different mathematics. This was like finding the same book written in five vastly different languages, such as English, Russian, Hebrew, Mandarin, and Swahili, but not knowing it's the same book. If a person doesn't know more than one of the five languages, he or she would likely assume all five books were different. But one who knows all five languages would instantly recognize that all five books tell the same story. And so it was with the five "different" string theories. A "Rosetta Stone" was found around 1995 that translated between the five theories.

This Rosetta Stone had an unexpected implication—it revealed that the fundamental particle of the theory wasn't energy trapped in the shape of a string, but actually energy trapped in the shape of a torus (or donut)—that is, a closed string with thickness.



**Fundamental Particle Discovered to be a Torus, not a String.** (from [Superstrings!](#))

The replacement of a string with a torus required an increased in the number of spatial directions from 9 to 10 in order to be mathematically consistent. And increasing the number of spatial dimensions came with unexpected, but nevertheless very profound implications.

First, the number of possible shapes of compact dimensions that needed to be investigated increased from a "mere" 100 trillion to *at least*  $10^{500}$  (that is a 1 followed by 500 zeros). This meant that finding the one shape in  $10^{500}$  that exactly describes our universe became exceedingly more difficult. But that was trivial compared to a second discovery that carried profound philosophical and theological impact. While the original 9+1 dimensional string theory was consistent with the existence of a single universe and its beginning from a standard Big Bang, the enlarged 10+1 dimensional theory is not. Instead, the 10+1 dimensional enlarged theory implies that not just one universe is created at a time, but rather that on the order of *at least*  $10^{500}$  universes can be created, each with *different, distinct physical laws*. Our universe, vast as it is, may be merely one of a vast number of universes.

Instead of a standard Big Bang to start one universe, about once every hundred billion to trillion years a new set of around  $10^{500}$  universes may likely be generated. The new universes would take the place of an earlier set of universes that has reached either a big freeze or big burn conclusion. The set of all such universes over all time has been named the *multiverse*. This universal renewal process could continue indefinitely into the future for the multiverse.

Earlier models of the multiverse indicated that it would be infinitely old, rather than have a distinct beginning. More recently, physicists have found

that the multiverse cannot continue infinitely into the past (this was shown in a recent series of peer-reviewed publications by leaders in the field). Thus, the multiverse has an overall starting time and is not infinitely old.

Thus, if string theory in its extended 10+1 dimensional form is true, the universe in which we exist is likely not the only universe created from a big bang 13.7 billion years ago. Rather, *at the beginning of our universe* God may have also created far more universes than we could have imagined prior to string theory. Many of these other universes might support life, but in vastly different forms than our atomic-based variety. Further, the starting time of big bang of our universe is not the same as the starting time for the whole multiverse. Rather, the multiverse as a whole likely began hundreds of billions, if not trillions, of years before the occurrence of the big bang that formed our universe and a vast array of others.

### **Theological Implications of the Multiverse**

Some find this picture to be troubling, but I believe that string theory and its implied multiverse provide a much deeper understanding of the whole story of creation. With the multiverse, the human perception of reality has grown and expanded by previously unimaginable orders of magnitude. With the dawning of the multiverse paradigm, Christians are thus able to perceive the creative nature of God on a scale and vastness as never before. The emerging story also has profound implications for theological views of God, including the meaning of God's transcendence, of God's immanence, and of process/open theology.

The historic Christian understanding of transcendence is that God is separate from His creation, this universe. That is, as Creator He is beyond both space and time of the universe. As St. Augustine described, God must in some sense "view" this universe in a 4-dimensional block form, with events of all times appearing "at once" in the same "picture." At the same time, immanence implies that the Creator God is

infinitesimally close to His creation and, further, through the Second and Third Persons of the Trinity, God is present within His creation.

To understand transcendence in the context of a multiverse, we must consider time in the multiverse. Each universe results from its own individual big bang and thus has its own concept of time as measured from within, independent and uncorrelated to the respective times measured within all other universes. Transcendence implies that God, as Creator, must be beyond the space and time of *each* universe within the multiverse. Further, there must also be some sense of overall global time in a multiverse frame from which specific times can be assigned for the occurrences of all the big bangs. Thus, transcendence also implies that, as Creator of the multiverse as a whole, God must furthermore be outside of the space and global time of the multiverse. That it, God is necessarily beyond the *block multiverse*.

In addition, God's immanence within the multiverse requires further theological contemplation, especially with regard to our understanding of the nature of the Second Person of the Trinity and His appearances within the multiverse. I believe God likely communicates with his sentient creatures in each universe through the advent of the Second Person of the Trinity in the physical form of the sentient creatures.

Such theological considerations are not unique to the multiverse. Rather, the possibility of life within other universes in the multiverse and the theological implications are simply many orders-of-magnitude extensions of the possibility of extra-terrestrial life within this universe and its theological implications. The Catholic Church (in particular) has contemplated the latter for several centuries. In fact, in the 1300's it was declared a heresy to state that other worlds like earth *could not* exist elsewhere in the universe. By the 1600's some Catholic priests proposed life elsewhere in the universe and contemplated the theological issues it raises. Pope Benedict XVI recently held an international conference at the Vatican on the existence of extra-terrestrial life, to which both

leading scientists and theologians were invited. According to Brother Guy Consolmagno (who holds a M.S. from M.I.T. and Ph.D. from the University of Arizona, both in planetary science), if new forms of life were to be discovered, it would not mean “everything we believe [theologically] in is wrong,” rather, “we’re going to find out that everything is truer in ways we couldn’t even yet have imagined.”<sup>1</sup>

Another specific issue to which the multiverse may be particularly informative is process/open theology. I believe the existence of the multiverse presents difficulties for process/open theology. Existence of more than one universe should raise serious issues for theologians who hold to the concept of God evolving with and within a universe. Since all universes within the multiverse would be causally independent of each other, a multiverse would imply that God evolves independently within each universe and has different knowledge in each universe (which is not consistent with monotheism), unless there was a way of defining a common “now” that applies to and overlaps all universes. While process/open theologians often define the co-moving frame of our expanding universe as the true frame defining the “now” in which God evolves and in which we interact with Him (through prayer for example), such a common frame to all universes within a multiverse does not exist.

Thus, process theology for a multiverse would require God to *choose* some type of common, universal “now” frame overlapping all universes and the multiverse. He would need to choose this *ad hoc* “now” frame to define, coordinate, and limit His own knowledge and evolution within and outside of each universe. In essence, multiverse process theology would require God to artificially choose a “now” frame by which He limits own His knowledge in all universes, in particular, and in the multiverse as a whole, to those events that occur before the common “now.” But, since it is an arbitrary choice, to choose this

“now” frame would require transcendence of the multiverse, in contradiction to process/open theology. (God would need to decide what multiverse events take place up to the “now”, and what events take place after—and then pretend He doesn’t know about the latter!) A God in essence pretending to limit His own knowledge for the sake of defining His existence within a multiverse “now” is not consistent with Anselm’s ontological argument for God. For then God would be that than which something greater *can* be conceived (a God that does not pretend these limits). Thus, I believe that, in the least, a multiverse poses severe difficulties to process/open theology.

### **Conclusion**

If string theory is proven correct, we may be nearing the next step in understanding the beauty, splendor, complexity, and vastness of God’s creation—far beyond anything we could have imagined before. This new multiverse paradigm shift would truly be of far greater magnitude and vastly more comprehensive than all those preceding. The science of today and tomorrow can, indeed, instill further awe and reverence for God, likely in ways unimaginable even a few decades ago

My overall goal of this essay was to show how scientific understanding of this universe, and of creation as a whole, can aid and support our Christian theological understanding and help it to grow. I pray that science and faith can be seen at more and more churches as mutually conducive and edifying. I hope my review of stages of human perception of our universe, of the history of our universe, and of a likely multiverse beyond our universe has contributed to this. I urge your church to join (if it has not already) the ever growing constructive interaction between science and faith.

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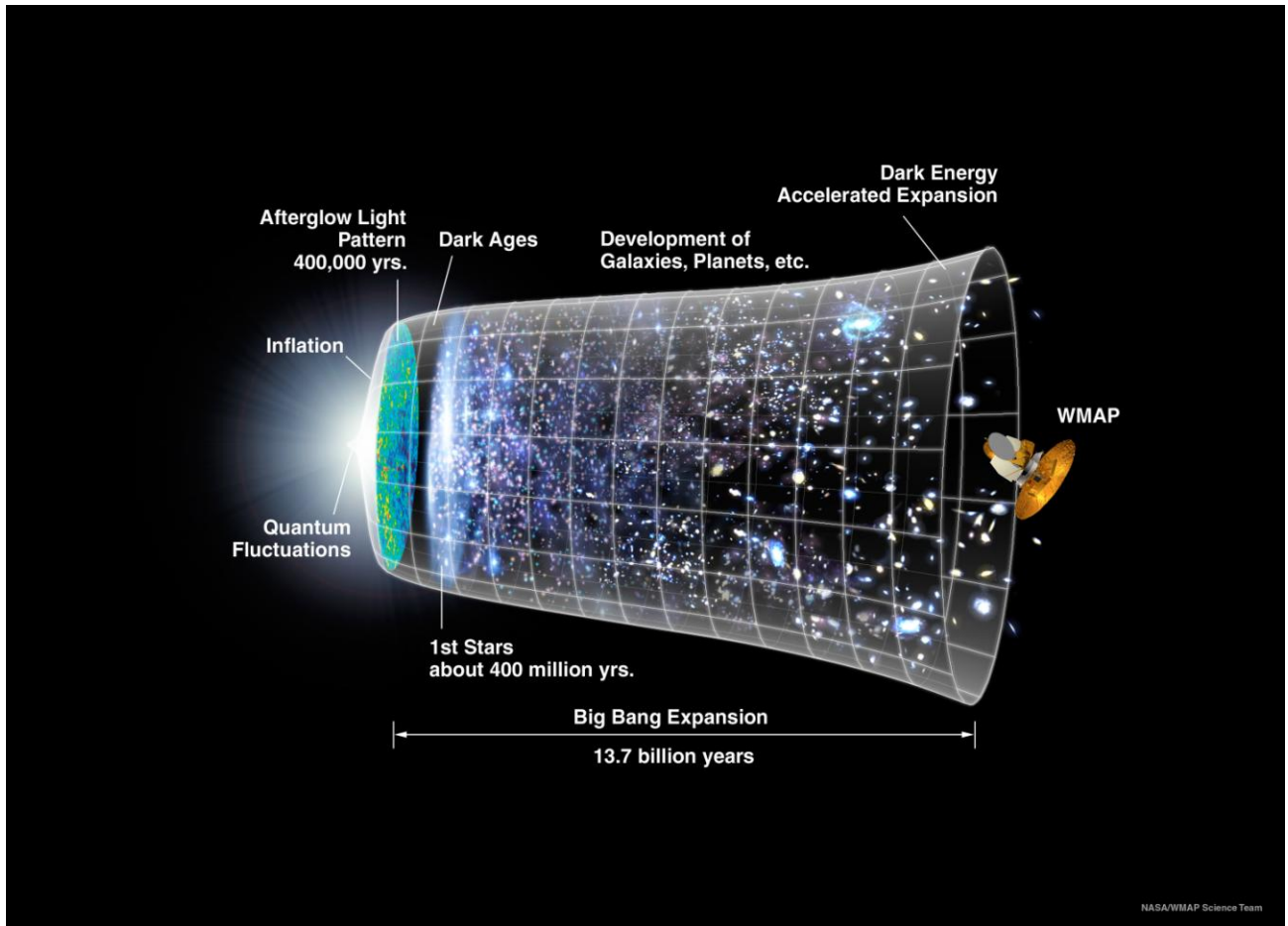
<sup>1</sup> <http://fatherroderick.sqpn.com/2008/05/14/vatican-astronomer-bible-full-of-extra-terrestrials>



in a hundred thousand) and the non-appearance of a theorized particle called a magnetic monopole.

The results of several independent “best-fit-to-data” experiments set the time of the Big Bang to be about  $13.7 \pm 0.1$  billion years ago. The 13.7 billion year general history of the universe from time zero to the present is well known. There are

no serious gaps in this history, other than what happened before a time of  $10^{-43}$  seconds after creation. Detailed charts relating the age of the universe, its temperature, its size, and corresponding physical processes, such as galaxy formations, are found in most cosmology textbooks. The diagram below illustrates that history.



**Verified 13.7 billion year general history of the universe.** (from [WMAP Science Team](#), [NASA](#))