A Christian Physicist Examines the Age of the Earth

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Dedication

I dedicate this work to my mother, Mary Ball, who encouraged me to read and to not be afraid of pursuing knowledge and truth, since all truth is God's truth.

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Introduction

Since you've picked up this booklet to at least skim it, obviously this subject is one of interest to you. I hope this is an issue you are willing to reason together with me, rather than simply checking to see if it agrees with your present view. If the former is true, then read on and I believe you'll find it interesting and worthwhile. I'm trusting that no one will put confidence in my conclusions concerning the age of the Earth simply because I claim to be a committed Christian or because of the Ph.D. in physics. Neither of these titles gives me enough authority to tell people what to believe. Rather I'm trusting that you are ready to reason with me, exercising as much skepticism as you like, but with just enough willingness to let the evidence persuade you of the truth. If not, I hope you'll at least read the first chapter. That doesn't address the age of the Earth, but rather why there is such a controversy over it among Christians.

Perhaps you feel this is a closed issue, based upon what the Bible says, and there is no need to examine it further. Or tragically, perhaps you feel a distaste for Christianity in general because it appears to require rejecting science altogether. For both individuals I have a message of encouragement. I have discovered a beautiful fit between good science and solid faith in Christ and the Bible. Now I feel compelled to offer my insights on this issue to others because of what I see as an unhealthy situation presently surrounding it. And not just to be heard, because I promised myself I wouldn't waste good paper unless I had something worthwhile to put on it. Although this is directed primarily to scientific laymen, I welcome scientists to examine this as well. From my experience, most scientists have not given much thought to the scope of these issues. We tend to be a little too specialized these days.

In case you are insisting on a quick and easy answer, then I won't beat around the bush concerning my conclusions. As a Christian physicist, I've been blessed with the freedom and opportunity to examine the scientific evidence for the age of the Earth in some detail, and have concluded that it emphatically points to an age of around 4.6 billion years. I'm well aware of the Biblical account of creation, and I can assure you that I strongly believe it to be true. As a Christian educator, I've had the opportunity to interact with Christian young people enough to know that this is an emotionally charged issue that is viewed to be high stakes with respect to the Christian faith. It is my intent to help people sort through this issue both with the mind and with the heart. Indeed, the age of the Earth may be the catchy title of this book, but the real issue is the role of science in influencing our faith, a nonscientific realm. It is my firm belief that those who are willing to go with me on this journey will come through it with their faith in the validity of God's Word, the Bible, strengthened, and with a greater respect for the testimony of the physical universe we live in.

Chapter 1
The Root of the Problem

On the first day of science class at a private Christian university, the wary freshman student is experiencing anxiety. Although the university is billed to be doctrinally sound, thoroughly evangelical, and unashamedly Christian, he is not sure how the science professors will stand on an issue that the student has determined to be an important litmus test of the faith. Anxiety is only heightened by the fact that the professor starts out class with a brief devotion, since this could be merely a deceptive appearance of faith, perhaps a faith badly marred by false doctrine. However the devotion doesn't give a straightforward answer to his question. The Scripture text is from Psalm 19 with emphasis on the first verse, "The heavens are declaring the glory of God; and their expanse is declaring the work of His hands" [1]. Some comments are made to the effect that the physical universe itself is providing us evidence of God's design, if we are willing to pay heed. But it would be much simpler if the professor simply came out and stated his position on this most important issue. Then the student could at least be more at ease, and know whether this professor is "safe" or not, indeed whether he can be trusted or perhaps he needs a good dose of apologetics to reveal the error of his way.

This scenario occurs regularly in my experience because I am blessed to be a professor of physics at a distinctively Christian university and have taught in such an environment for nearly 10 years. No, I don't always start the school year off with a devotional from Psalm 19; however I do love the Psalms and frequently draw devotional material from them. And just as the physical universe seems to be sharing consistent messages with us from many different directions, the Bible also provides us consistent messages from its 66 books. But the tension of students waiting to find out where I stand with respect to the line drawn in the sand concerning the age of the universe is a very present one.

"Creation Science"

This line in the sand can be easily understood from what has happened in many of the mainstream conservative evangelical churches of North America over the last few decades. What has become commonplace is the acceptance of "Creation Science" as the only acceptable approach to how science and the Bible should relate. In a nutshell, the premise of Creation Science is that the Bible gives us answers to many questions also addressed by science. The Bible, which is held to be the inerrant, infallible Word of God, cannot be wrong. Therefore, when the Bible and science disagree (or appear to disagree), the latter must be wrong. There is no room for questioning this premise. You must simply choose which side of line you stand on, the Bible or science.

Ironically, Creation Science actually goes one step further, and seeks scientific support for the perceived Biblical answers. All scientific evidence that appears to disagree with the Bible must be somehow in error (e.g. Henry Morris' analysis of Sue, the most complete Tyrannosaurus skeleton yet unearthed [2]), since the Bible has already given us the answer. Concerning the age of the Earth, the Bible's genealogical records combined with the Genesis 1 account of creation are used to estimate an age for the Earth and universe of about 6000 years, with a bit of uncertainty on the completeness of the genealogical records, allowing for a few thousand years more. This young age is repeatedly confirmed by numerous studies done by proponents of

Creation Science. Yet the vast majority of the scientific community claims there is abundant scientific evidence that points to an age of 4.6 billion years for the Earth and about 14 billion years for the entire universe. Who is right?

No amount of semantics can give validity to both claims. Interestingly enough, attempts have been made. One suggestion uses Einstein's theory of relativity, in which time measurements are relative to the observer's reference frame to propose that both a 6000 year old Earth and a 4.6 billion year old Earth are possible [3]. However, extremely different reference frames are required, one of which will be moving at nearly the speed of light relative to the Earth. In a reference frame moving in a very rapid round trip away from and back to Earth, one can measure a very short time elapsed, while eons have passed by on Earth. But only in the reference frame of the Earth does one measure a meaningful age for the Earth. And there is no ambiguity in the measurement of this time. Another attempt to include both young and old ages involves exaggerating the scientific uncertainties to the point that neither can be excluded [4]. This grossly misrepresents the scientific evidence, which has provided us abundant and sufficiently accurate indicators of the Earth's age to settle the question. The cold hard conclusion is that someone must be wrong here.

Many Christians are afraid to even suggest that the 6000 year age could be wrong, since that might be suggesting the Bible is wrong. But then again, a massive conspiracy of manufactured false evidence from many fields of scientific research for an older Earth and universe is a bit farfetched even for conspiracy fans. We will look into many of these evidences in the coming chapter. While we are at it, we should also consider evidences put forth by proponents of Creation Science favoring a young Earth, and evaluate their merits. Are they the lone proponents of truth in the midst of a perverted world of science? Or are there problems with their proposed evidences? The following chapter examines some of these.

Origins of the Controversy: Darwinism

But before we begin, there is a need to take a step back and get a broader view of the origins of this controversy. Although the age of the Earth is a topic I am more qualified to discuss than the following one, it is essential to understand what has influenced the emotionally charged climate in the first place. Fortunately, there is little disagreement concerning this root cause. All of it leads back to the issue of Darwinism. For nearly 150 years debates concerning the meaning and consequences of the theory of evolution as proposed by Charles Darwin have continued in various circles, particularly in the church. Darwinism is a term representing the theory of evolution in combination with particular meaning and consequences attached to it. There are many good resources documenting the history and development of Darwinism and its opponents [5,6]. But to summarize, it was the meaning and consequences given to the theory of evolution, which forced its rejection in whole by much of the Christian church.

Indeed, even the verb evolve has often taken on unfounded meaning beyond its simple definition "to change with time". Within the scientific community, the word evolve is used without fear of conveying anything more than this. However the scientific layman usually attaches more meaning to it, conveying images of Darwin's theory and certain philosophical perspectives, particularly "philosophical naturalism", a presupposition that all physical phenomena must have explanations that are non-supernatural ones. Some go a bit further and suggest that there is nothing in the universe other than what can be physically observed and measured, thus

eliminating the supernatural from the outset. Yet this violates the sensibilities of many people, since consciousness, freewill, morality, and many other realities defy scientific understanding.

However, the theory of evolution itself is presented primarily as a scientific study in Darwin's "Origin of the Species" [7]. It simply proposes that all of the species of life present in the world today came into existence through slow, gradual changes in its ancestors going all the way back to ancestors common to all species today. Central to the theory is the proposal that these changes are brought about by physical processes at work in the environment, which we can observe today. The stirring effect of this theory is not what it says about God, but rather the absence of any statement of God's role. This made Darwin's theory immediately the subject of controversy in 19th century England, where all of the individual species of life were attributed to separate acts of creation. The controversy would soon spread to America and other English speaking countries.

Why the controversy? Genesis describes the creation of the world with special emphasis on the creation of mankind. Man is described by Genesis 1 as being "created in the image of God", a rather profound way of stating something about the kinship man was intended to have with God above and beyond that of any other species of life on Earth. We shall return to this reference in the last chapter. Because Darwin's theory makes no distinction between man and other life on Earth, it was met with resistance from the very start. Although some Christians today accept both the validity of the Bible and of evolutionary theory as proposed by Darwin, early proponents of evolutionary theory recognized an irreconcilable problem. Either man is fundamentally different from other life forms or he is not.

Varying Responses: Science and the Scriptures

An apparent way out of this dilemma is to suggest that man is different in that he has a spirit, which is eternal, while having a physical body, which is very much in the likeness of other life forms. The former actually agrees with how God is described in the Bible, One who is Spirit rather than flesh and blood (John 4:24). So then can man be created in the image of God and have a common ancestry with other life forms? Here the Bible has something more to say. In Genesis 2:7 man is depicted as having been formed from the dust of the ground, a special act of creation. Beyond any doubt is that God's direct intervention in creation is the clear message given by Genesis. How can God be directly intervening in creation while man's existence is attributable to physical processes at work? This is a question difficult to answer. It is much easier for one who believes in a Creator to reject any role that science might have in explaining origins, whether it be origins of the universe, of the Earth, of life, or of mankind.

Here we have the reason for such a varied response by the Christian community to the threat of Darwinism. The response is heavily influenced by how one views the relationship of science to the Scriptures. Some view science as merely a human construct, and therefore when it appears to disagree with the Bible, it must be that science is wrong; for only the Bible is held to be the lone source of truth as revealed by God to man. Others recognize that science is the pursuit of knowledge based on discovering the laws and principles governing our universe, of which God Himself is the author. So it follows that science and the Bible should be giving us consistent messages by virtue of the same authorship. When they appear to conflict, it could be a problem in our understanding of science or of the Scriptures.

Yet even of those who have a healthy respect for the role of science, there are differing responses to Darwinism. One recent movement attempts to show from the scientific evidence that all species of life were created via supernatural intervention, leaving us complex designs of whose origins science cannot provide an adequate explanation. This is the "intelligent design" movement, prime examples of which are provided by Michael Behe in his book, "Darwin's Blackbox" [8]. Highlighted is the absence of any plausible explanations for the evolution of "irreducibly complex" biological systems, particularly from a biochemical perspective. Naturalistic explanations are ruled out as inadequate to explain the complex machinery of the biochemical realm, something many advocates of evolutionary theory have been treating too simplistically. A very convincing and respectable case is made. But this movement has been criticized for relegating the unexplainable to a Designer, where the lack of scientific explanations becomes its source of support. For some scientists, this is too reminiscent of the "God of the gaps" approach, where the gaps in our understanding of origins are attributed to the hand of God. The premise becomes a losing one if plausible explanations are found. But is it really necessary to rule out naturalistic explanations? In other words, can science speak concerning a Designer on the basis of what can be understood scientifically? I believe so.

Unclear Evidence for Evolution

While there are numerous philosophical and theological problems involved in addressing evolution and the Bible, it is also difficult to get clear picture of the scientific issues. From the author's perspective, most sources addressing Darwin's theory give a biased presentation of the scientific support for evolution. Either the source is a criticism of evolutionary theory, highlighting many irresolvable problems of the theory. Or the source is an attempt to defend evolution as a valid scientific theory, which has a great body of supporting evidence from many different fields of research, placing the theory's validity beyond question. A typical example comes from a recent statement issued by the National Association of Biology Teachers: "Recent findings from the advancing field of molecular genetics, combined with the large body of evidence from other disciplines, collectively provide indisputable demonstration of the theory of evolution" [9]. Most people who have considered the evidence for the theory of evolution recognize that this is very misleading. Evolution is "indisputable" only to those who simply will not consider any alternative, not because the supporting evidence is really that overwhelming. Alas, it is difficult to find any material that fairly presents both the strengths and the shortcomings of the theory of evolution. The readers are placed in the unfortunate position of having to decide what the objective facts really are, or to simply trust some reputable authorities on the issue.

I will mercifully spare the reader by not delving deeply into the merits of the evidence for and against evolution. However, to avoid this altogether would be sidestepping an important issue. So I offer my thoughts. From a scientific perspective, Darwin's theory appears to have supporting evidence from a number of fields (comparative anatomy, the universal genetic code of DNA, geographical distributions of species, the overall progression of life in the fossil record, among others) [10,11]. Yet, upon closer inspection, there are observations that pose severe difficulties for the theory (the rapid emergence of life on Earth, the Cambrian "explosion" of complex and diverse life, the poorly understood mechanisms of biochemical evolution, the general pattern of stasis in the fossil record, among others) [12,13]. Supporters of evolutionary theory see the problems as simply unresolved issues that will eventually be met with scientific explanations, whereas opponents of the theory see them as severe enough to invalidate the theory

of evolution altogether. What can be fairly stated is that the theory of evolution is a scientific theory with some supporting evidence, yet several key steps required in the theory of evolution are not yet understood.

As a scientist, I support further research into the origins of life. Darwin's theory should stand or fall on the basis of scientific evidence. In fact, I fully expect that some of the pros and cons of the theory mentioned here will soon change, perhaps becoming resolved with clearer understanding or developing into more of a crisis of the theory's inadequacy. Crises have served to overthrow some of the most deeply entrenched (and incorrect) theories in the past, simply because there were enough thinking people who cared about establishing the truth. Statements issued by influential groups cannot decide it; only solid evidence and clearer scientific understanding can serve to establish the theory's validity.

But alas, so much public distrust has already been generated by the attempts to give a one-sided picture of the evidence. A large segment of the Christian community has no faith that the scientific community would be forthcoming with evidence conflicting with Darwin's theory. Furthermore, proponents of evolution tend to belittle those who reject the scientific evidence altogether. No common ground for reason is found. The recent controversy over the teaching of the theory of evolution in the State of Kansas illustrates this problem well [14]. It was as if the battle was between those who uphold science and those who uphold Scripture. Where was the voice of those who have a healthy respect for both? It was ignored by the media because it didn't add fuel to the controversy [15]. This voice wished to express strong reservations both about the teaching of Creation Science as well as the dogmatic insistence that the scientific evidence strongly supports the theory of evolution. Equally important, it might have diffused much of the controversy to limit the teaching of Darwin's theory to the scientific aspects, thus leaving the "isms" that have been associated with it out of science classes.

Unfortunate Resulting Climate

So what has all of this to do with the age of the Earth? Quite simply put, Darwin's theory of evolution becomes entirely impossible if the Earth is very young, such as 6000 years old. The vast time required for small variations to accumulate into major changes in the species was recognized as necessary by Darwin, when the age of the Earth was very much unsettled. Although establishing an old age for the Earth does not establish the validity of Darwin's theory, if one could show the Earth is young, the entire matter is settled. And thus all of the "isms" which rest upon the validity of evolution are invalid. This is a most unfortunate route chosen by several evangelical Christian groups. Now, rather than just opposing some outspoken atheistic evolutionary biologists, virtually the entire scientific community, which recognizes a vast amount of evidence for an older Earth and universe, is to be opposed as corroborating evolutionists.

Amid the wreckage of this battlefield people are left to try to sort out what really makes sense. Although this book is addressed to Christians and non-Christians alike, here I offer some advice for my fellow Christians. Much of this fighting has been viewed very negatively by the non-Christian community. Forcing the public schools to teach Creation Science would not win non-Christians over to Christ. Certainly not when the premise itself is that science is wrong when it seems to disagree with the Bible. While the scientific community can be faulted for harboring contempt for those who don't accept the commonly held theories, I would hold my fellow

Christians to a higher standard. It does no good to belittle the scientific community. In fact Christians everywhere would benefit from a more healthy respect for science in general. I believe we would find science to be one of the greatest allies of the faith.

Many scientists who accept an older Earth have clear Christian faith commitments. Fortunately, most individual Christian brothers and sisters recognize that this does not compromise their faith or their love for God. The admonition given by Paul to Titus, to "shun foolish controversies and genealogies and strife and disputes about the Law; for they are unprofitable and worthless" [Titus 3:9], is heeded by mature Christians. But the position of many churches is that these scientists are misguided Christians or worse, as out-and-out enemies of the faith, like the "tares" planted by the enemy of our souls. Meanwhile, proponents of Creation Science work to prevent a reappraisal of this issue by the Christian community as a whole. By claiming that an acceptance of an older Earth is just the first step towards a slide down a "slippery slope" of rejecting Biblical truth in general, much fear and emotion has been generated.

God Himself called upon His people to "Come now, and let us reason together" [Isaiah 1:18], which should temper our responses to those whose opinions differ. Sometimes labels are cast out in an attempt to discredit a position, in place of sound reason. Those who accept an older Earth are portrayed by a segment of the Christian community as "liberal". But rather than labeling people for their view on this issue, shouldn't we be willing to carefully and humbly consider the evidence? Is it really clear that one's position on this issue implies acceptance or rejection of Biblical truth? The final chapter discusses reasons why this is not so. You are not being asked to acquiesce to the claims of science just to avoid offending the scientists or to accept the Bible with blind faith. Rather, you are asked to consider the evidence and the Scriptures to see that they are not in conflict, but form a remarkable consistency. Jesus said "if you continue in my word, you shall know the truth, and the truth shall set you free". The wonderful truth that I have realized is that there is no need to be afraid of science, since it truly does uphold the Word of God. Such a realization sets one free from fear and misplaced emotion, and allows one to see the beauty of science.

A Healthy View of Science and the Scriptures

This brings us to a primary theme of this book. If we consider how scientific understanding impacts the Christian faith we are led to the question, "Can God be actively at work in a world in which scientific laws and principles provide explanations for what we observe?" While an affirmative answer to this question may not seem to pose any difficulty, let me be a little more explicit about what this forces us to consider. Does a scientific explanation preclude God's handiwork, or can both be present? Furthermore, can a scientific understanding actually provide support for God's intervening handiwork? Or must we relegate only those things that science cannot yet adequately explain to the role of the Creator? If God is the author of the laws and principles governing the universe, can they not serve to accomplish His will? Psalm 119:91 claims "For all things are Thy servants". While we cannot require God to obey these laws, we need not require God to violate them either. As the now popular Christian saying goes, we should not put God in a box. Many miracles described in the Bible may not be understood scientifically, but they are accepted by faith. Likewise, the hand of God may be evident even when science provides us a measure of understanding.

This author proposes that we try to look at the scientific evidence without any theological filter. Let the scientific evidence have an independent voice from that of the Bible. Then, and only then, can it provide independent support for or a denial of the claims of the Bible. Let me remind the reader that although science is a human enterprise, conducted by fallible human beings, the scientific evidence is being gleaned from the universe, which is the handiwork of God. Psalm 19 has promised us that the heavens are declaring the glory of God. I take that to mean that the physical realm we live in is telling us something that we need to hear. The scientific evidence provided by the universe can lead someone to a personal search for the One who created it. We should not deter people from this search by requiring them to reject the very science that is prompting them. We should welcome that independent voice as another confirmation God is giving to a skeptical generation of His handiwork. It speaks of a God who can be known, since He cared enough give such consistent messages to us. The Bible speaks not only to who God is, but how we can know Him personally through Jesus Christ, His Son. Once that is settled, the age of the Earth becomes a minor issue in comparison. But for the sake of those needing some evidence, let us now address the age of the Earth.

Chapter 2
The Scientific Evidence

You don't have to have an eyewitness account from someone to determine when something in the past occurred. You simply need sufficiently trustworthy evidence left behind in order to make an intelligent determination. For example, a coroner can determine when a person may have died based on the body condition and its temperature compared to both the surrounding environment and the original living body temperature. Although there may be complications, which increase the uncertainties in the actual time of death such as a changing temperature of the environment, it is still possible to make reliable estimates. In fact, the evidence left behind can be a more reliable source than a living eyewitness with a watch, as the next example will show.

Differing Time Frames in the Universe

Before becoming a primarily teaching faculty member in Christian higher education, I worked as an experimental high energy physicist, studying the properties of the most basic, fundamental particles in nature. In experimental high energy physics research, it would be rather absurd to stick a person inside of our detector region, near where high energy particles are collided and numerous new particles are generated from this energy. Beyond the problem of intense radiation exposure, this person would be a completely worthless witness. Limiting the scope of instruments to human senses alone, one would conclude that nothing happened, at least until becoming extremely sick from radiation exposure. We must rely upon much more sensitive instruments, which can measure space intervals of nanometers and time intervals of nanoseconds in which these elusive elementary particles existed. By using sensitive instruments we have discovered that the existence of many particles is typically nanoseconds or less, before the particle that is produced in the lab has disintegrated into other particles [16].

This is why it is not difficult for a researcher in high energy physics to accept that there are vastly different time scales for the "lifetimes" of objects in the universe. In referring to lifetimes of nonliving objects, I do not attribute some kind of conscience existence to them, rather that they are created and at some later point no longer exist as such. If I can accept that a subatomic particle has a lifetime of less than a nanosecond (0.000000001 second), while my lifespan is over a billion seconds (1,000,000,000 seconds or 32 years), then I can accept that the lifespan of a star is much longer than mine. One can calculate the rate of fuel being burned inside the core of a star and estimate its lifetime, approximately 10,000,000,000 (10 billion) years for our Sun, of which present indicators reveal that nearly half of its lifetime supply of fuel is exhausted [17]. The underlying premise is that we can use the presently existing evidence garnered by reliable instruments to help us determine when something took place in the past.

This is the basic premise for all of the scientific evidence used to estimate the age of the Earth. But we must be willing to shed the naive assumption that all processes in the universe happen in a time frame similar to ours. The reliability of the evidence can be determined in a number of ways. First of all, since our universe obeys certain laws and principles, the evidence should be examined in light of these well-established laws and principles. Secondly, when several independent sources are all giving very similar answers, it increases the measure of confidence we have in the results. Good science requires both the measures of self-consistency and consistency with other independent, yet equally valid methods. While we may not be able to

reproduce in our laboratories the major events that have occurred in the history of the Earth, we still have criteria for establishing good science in our investigations of them.

The evidences we will briefly examine come from the fields of geology of the Earth, radiometric dating, lunar and planetary geology, meteorite specimens, stellar astronomy, and cosmology. While the first two fields deal with the Earth itself, it is quite valuable to look for confirmation beyond the Earth itself. We will see that this broad spectrum of data yields a very consistent overall picture of the history of planet Earth and of the universe. And it is not an exhaustive spectrum of the evidence. I merely limit it to these for the sake of brevity.

Geology of the Earth

Just one glimpse of the multitude of layers of rock exposed in the Grand Canyon is an awe-inspiring experience. The wearing action of water cutting downward through solid rock has exposed a sizeable amount of Earth's history all in one sweeping landscape. The shades of color from one layer to the next going down over one mile deep from the canyon rim down to the Colorado River tells us that there is an incredibly vast and changing history associated with how these layers were deposited. We find fossils in many of these layers, showing the history of life forms going backward in time as you go down through the successive layers to earlier time periods. The fact that the fossils change from layer to layer indicates dramatic changes in the environment and in the species of life populating the Earth.

It is not easy to estimate the rate of rock layering, since this fluctuates greatly in time, such as the steady marine sedimentation during below sea-level periods versus the variable rate of soil build up while competing with natural erosion on land. However, it is clear that vast intervals of time are necessary to produce the layers of rock we do observe. This means much more than a few hundred years, or even a few thousand years. While precise dating based on geological principles alone cannot be made due to the variability of sedimentation rates, a minimum of several hundred million years is certain. Using radiometric methods described shortly, scientists estimate that fully one-third of the Earth's history is exposed in the Grand Canyon, corresponding to over 1.7 billion years of deposited rock layers [18].

One common misconception concerns what fossils are. It is important to understand what they are not, namely old hardened bones. Fossilized bones contain virtually none of the original bone tissue. Only the painstakingly slow process of replacement of bone tissue with minerals from the surrounding soil can produce a true fossil. This replacement takes place one microscopic grain at a time, until the entire bone has been changed from a bone into literally a stone. In the same way, petrified wood contains none of its original cells; it is changed into stone as well, often beautiful mineral gemstones. Since most bones of dead creatures decay away before this process can occur, fossils can very rarely form. And since there appears to be an abundance of fossils in the Earth, it is clear that there has been an incredibly long history of life preceding us.

Other geological studies have examined processes believed to be rather constant in time such as rates of coral reef build-up, tectonic plate motion, mountain building, certain weathering and erosion rates, and even the rate of continental mass build-up. All of these yield a minimum of several hundred million years of time necessary for what we see today to have been produced. We actually have ways of showing how these processes must have been occurring at fairly constant rates throughout their histories. The process of coral reef formation is by nature a

gradual build-up. Tectonic plate activity is recorded in successive layers of rock being pushed outward while new rock is deposited on the ocean floor surrounding the mid-Atlantic Ridge. Both reflections of laser light off of the Moon and the pattern of rock deposition show this to be a slow, continual process. Furthermore, consideration of whether all of these processes could have been much more rapid at some time in past leads to some absurd consequences. For example, any faster tectonic plate motion in the past would have been accompanied by extremely violent earthquakes that would have left many other evidences behind in their wake. And these are but a few examples of how studies of the Earth's geology yield vast time periods. Yet it is not quite possible to pin down the age of the Earth from any one of them for one reason. None of these processes have been uniformly constant since the Earth was formed.

Radiometric Dating

Radiometric dating is the method of using nature's natural clocks to date events such as when rocks were first formed. Once again, as with the coroner faced with determining the time of death, we find that the evidence left behind can speak for itself. These natural clocks consist of elements having certain members or isotopes, which are radioactive, meaning they disintegrate into other particles after a certain time. While it is impossible to predict exactly when one of these will disintegrate, is it very possible to predict what a large sample will behave like, since each isotope has a characteristic lifetime. Just as the number of radioactive isotopes will decrease in time, so will the rate of disintegrations, until that level is below our abilities to detect them accurately. Therefore the lifetimes of these isotopes will limit the range of their usefulness in dating past events.

Methods of atomic mass spectroscopy have provided accurate determinations of levels of carbon-14, a common isotope used to date formerly living remains up to a hundred thousand years. But it cannot test for ages beyond this, since the half-life (time necessary for half of the original sample to disintegrate) of carbon-14 is only 5730 years. It takes only 20 half-lives for the original sample to be reduced to less than 0.000001 (one millionth) times the original amount, thus making it virtually gone for all practical purposes. It is important to note the level of carbon-14 in the environment must be fairly constant for the method to be accurate, since while the remains in question was alive, it would have had a level of carbon-14 equal to the environment at that time. This level has been influenced by cosmic ray activity, which could have fluctuated over time. By testing expected carbon-14 levels in tree rings over several thousand years we have found this level to vary as much as 10% [19]. Thus carbon-14 dating is used to date remains of former life up to several tens of thousands of years with limited, yet reasonable accuracy. But we cannot use it to date things much older.

So how do we arrive at billions of years from radiometric dating, given this limitation on carbon-14 dating? We must study older objects, such as rocks, and use radioactive isotopes with much longer half-lives. Fortunately, there are many such isotopes. The more common ones include Potassium-40, Uranium-238, Thorium-232, and Rubidium-87. These have half-lives of 1.3 billion, 4.6 billion, 14 billion, and 49 billion years [20]. Once again, just as the coroner may have to work against some unknowns in the environment, the original amount of the "parent" isotopes in a rock sample may be unknown, as well as the pre-existing levels of the "daughter" isotopes resulting from their decays. However, by sampling many different parts of a rock formation and comparing the parent and daughter isotope ratios relative to stable isotopes, we can perform crosschecks, which can either tell us reliably what the original levels were, in

addition to the age of the rock, or whether contaminations render the measurements unreliable [21]. Contrary to the assumption needed in carbon-14 dating, now the original levels need not be assumed at all, since the parent and daughter isotopes are contained in the rock. Studies of radiometric dating using a variety of different isotopes lead to consistent measurements for ages of rocks, some as old as 3.8 billion years, such as found in the Isua formation in Greenland [22]. Most rocks on Earth are not nearly that old because of the continual patterns of geologic activity, weathering and erosion, which continually reshape the Earth's surface.

Many criticisms have been leveled at radiometric dating, claiming it is flawed by some unfounded assumptions. Incorrect measurements are possible. However, it is overlooked that measures of independent verifications of radiometric ages are often available, and they clearly favor the accuracy of radiometric dating. One very simple measure of consistency is the fact that no isotope is found naturally occurring on Earth having a half-life less than a few million years (with the exception of a few isotopes which are short-lived intermediates of much longer lived radioactive isotopes or cosmic ray products), of which many dozens have been produced in the laboratory. One well-known example is Plutonium-239, which can be produced through nuclear reactions with Uranium-238. Plutonium-239 has a measured half-life of only 24,000 years. Fortunately for us, none is found naturally occurring in our environment. Even Neptunium-237, which has a 2.14 million year half-life, is not found naturally occurring. A sufficiently old Earth may have had many of these isotopes present in its infancy, which by now are long gone due to their relatively short lifetimes. If however the Earth were very young, there would be no particular reason for their complete absence, especially when all of the long-lived isotopes such as Uranium-238, Uranium-235, and Thorium-232 are found in abundance. It would be a very peculiar coincidence. Just as a coroner would conclude that a body that has already reached the same temperature as the environment has been dead for quite a while, we can confidently conclude that the Earth has been around for quite a while, much longer than a few million years.

Lunar Geology

Precise dating of the birth of our Earth is difficult based only on knowledge of the Earth's geology and radiometric dating of its rocks, primarily since primordial rocks may not have formed until long after the Earth's initial formation. If the formation of planet Earth happened in a way consistent with our understanding of solar system formation from basic physical principles, then extreme conditions in the early Earth would have resulted in very high temperatures for quite a long while. Actions of gravitational contraction, gravitational differentiation of elements, high levels of radioactivity, and heat convection and radiation processes would have required a long time of cooling before sufficiently low temperatures were reached to allow rocks to form. So while no rocks can be found older than about 3.8 billion years old on Earth, the Earth itself is older than this. We must go outside the Earth to get a more accurate measurement, namely the Moon. This is what made the Apollo missions so important to scientists. The Moon is geologically inert and has no atmosphere, thus the stable conditions should have preserved the history of our solar system much better than on Earth. Rocks brought back from these missions have been dated up to 4.3 billion years old, confirmed through measurements using several different isotopes [23].

Meteorites

But even the geologically inert Moon does not have rocks dating back to the birth of our planet, since it too required a substantial period of crust formation, due to its own internal heat and a large early bombardment of meteors whose history is still etched onto the Moon's surface in the form of innumerable craters. Indeed, we see such meteor craters covering the surfaces of all planets and moons in the solar system that have been geologically inert. However, meteorites themselves actually provide us with some of the most pristine samples of the earliest period of the solar system. Specifically, meteorites found on Earth appear to have been essentially isolated while spread out in the solar system, until eventually being captured by the Earth. While iron meteorites have been found not to have the long-lived radioactive isotopes needed for dating, they are invaluable for dating the Earth, since they provide us with pristine samples of primordial lead, whose isotopic ratios yield the original lead isotopic ratios on Earth, which have since then been modified by the daughter products from Uranium and Thorium decays. By this method we find the Earth to be 4.6 billion years old [21]. This is confirmed using stony meteorites, which have been dated using Rubidium decays [24]. In fact, nearly all meteorites are dated to within 1% of their mean age of 4.53 billion years [17], indicating that they truly have been isolated since the birth of our solar system. During this earliest period the Earth would have been in its initial stage of formation, a much different Earth than we see today.

Stellar Astronomy

Are there non-radiometric methods, which can be used to determine such vast ages? Yes, and the natural clocks they depend upon are very reliable. If you can count on the Sun rising in the morning, then you can put faith in the process by which its energy is produced, the process of nuclear fusion. Nuclear fusion is a powerful source of energy we can understand by means of Einstein's famous equation, $E = mc^2$. Energy is equivalent to mass. Nuclear fusion is the process whereby mass is converted to energy. The primary constituent of the Sun is the lightest element Hydrogen. When Hydrogen is fused together with other Hydrogens to form heavier elements such as Helium, matter is converted into energy and given off in the form of new particles such as photons and neutrinos. This energy conversion has been occurring steadily in the core of our Sun, where temperatures are sufficiently high enough, for as long as Earth has been around, thus bathing the Earth with heat. From the rate of energy produced and the supply of fuel initially inside the reaction core of the Sun, we can determine its lifetime. As mentioned previously, this is approximately 10 billion years. Stars the size of our Sun or smaller burn their nuclear fuel at a fairly steady rate during nearly their entire lifetimes. The present brightness and temperature of our Sun indicate that nearly half of its lifetime supply has been exhausted so far [17]. Specifically, solar models indicate that it is approximately 35% brighter today than when it began its nuclear fusion process. But don't start worrying about its eminent depletion yet, since it has another 5 billion years worth of fuel left.

Other stars have been dated to be much older than ours, up to 14 billion years old. In fact, innumerable stars have already exhausted their supply of fuel and met their deaths. A star dies by running out of the very fuel that sustains an outward pressure to prevent its own self-gravity from collapsing it. The larger stars die rather violently, in a process called a supernova. These titanic explosions thrust matter, including some heavy elements, throughout interstellar space and contribute to new star formation elsewhere. In fact, it is necessary that a few cycles of this re-seeding of star formation with new matter to have occurred prior to the formation of our solar system. Otherwise the heavy elements, which are so abundant in the Earth, would not have been present in sufficient amounts. We can verify this by checking the oldest stars in our galaxy for

heavy element composition. Without exception, they are all deficient of heavy elements [23]. The heavy elements have been produced in nuclear fusion cycles of massive stars. What does this tell us about the age of the universe? It tells us that the universe must be significantly older than our solar system. Our best estimate presently is that the oldest stars formed nearly 10 billion years before the birth of our Sun.

The Universal Expansion

Another crosscheck on the age of the universe itself comes from a study of the expansion of the entire universe. We refer to the study of the origins and development of the universe as the field of cosmology. We've learned some surprising details from looking at light arriving to us from the remotest parts of the visible universe. One thing we've learned is that the visible extent of the universe is exceedingly vast. Light itself, moving at the incredible speed of 186,000 miles each second, would have needed over 10 billion years to traverse the extent of our universe we observe today. This also means that the light now arriving to us from the most distant visible objects began their journey over 10 billion years ago. The Hubble Space Telescope is giving us beautiful images, which are in essence snapshots of the universe when it was much younger.

How do we extract an age for the universe? Astronomer Edwin Hubble demonstrated in the 1920's that the universe is expanding; by showing that the further away a galaxy is from us the faster it appears to be moving away from us. This expansion rate tells us how long the universe has taken to expand to the immense size it is today. But it has been very difficult to determine this expansion rate accurately until recently. Modern telescopes have been able to image individual stars up to 100 million light-years away, and individual galaxies and supernovae over 10 billion light-years away. To appreciate the power of such instruments one should compare it to the magnifying power of the best microscopes available today, namely scanning tunneling microscopes, which can resolve atomic shapes one billion (1,000,000,000) times smaller than the width of a human finger. The stars we can now image are over 6 trillion (6,000,000,000,000) times further away from us than our own Sun is, and individual galaxies and supernovae over 100 times further away than that. Clearly the vast distances speak of vast ages as well. Combining measurements of several different distance indicators such as variable stars and distant supernovae, we have narrowed down the age of the universe to approximately 14 billion years old, uncertain to 0.5 billion years [25].

The Cosmic Microwave Background Radiation

Additional evidence of a beginning 14 billion years ago is the leftover remnant of the initial explosion nicknamed the "Big Bang", which was discovered first in 1965, nearly 20 years after it was predicted. This is the Cosmic Microwave Background Radiation (CMBR), which pervades all of space. It is the radiation released near the beginning of the universal expansion, and has been cooling off gradually ever since, until today it is now a chilly 2.73 degrees above absolute zero temperature. The initial temperature is well known, since it is the same temperature at which electrons are freed from Hydrogen atoms, the primary constituent of our universe. It tells us the universe had a very uniformly hot and compact beginning, cooling down as it expanded to where Hydrogen atoms could form from the electrons and protons, thereby releasing the radiation, followed by continued expansion and considerable cooling during the following 14 billion years [26]. This is truly a remarkable story the universe is telling us. Once again, just as the coroner investigating a cold body concludes that a long time has past since its death, the

evidence is telling us a consistent message concerning the age of the universe. All of it points to an Earth that is 4.6 billion years old and a universe that is 14 billion years old.

It is important to point out at this stage in our examination of the ages of the Earth and universe, that neither is infinitely old. While the evidence speaks of vast ages, it also clearly speaks of a beginning as well. Furthermore, the very laws and principles governing our universe today cannot be used to extrapolate any further backwards in time than to within a small fraction of a second of creation itself. Not only are the laws of physics incapable of telling us what happened at the very beginning, application of these laws lead to the conclusion that all matter had a beginning, also space and time itself. Thus while we are able to learn much concerning the age of the Earth and universe from science, it cannot speak clearly concerning what started it all. Indeed, science merely echoes the words of Genesis 1:1, "In the beginning, God..." One who cannot be constrained by the very universe and laws He created.

Chapter 3
Evidence for a Young Earth?

At this point, it may appear to the reader that conspicuously missing from the list of scientific evidences are the evidences for a young Earth. I can assure you that it isn't an oversight. Their absence certainly isn't due to a lack of proposed evidences. In fact there are far more of these than the number I have discussed in the previous chapter as evidences for an older Earth. But I hope we can agree that numbers do not equate with quality. Am I biased against these proposed evidences? Only in the sense that they don't exhibit the criteria established for good science. Important measures of self-consistency and consistency with other observations are lacking. While I don't enjoy taking the wind out of other people's sails, I must be honest about this. I have yet to see any convincing scientific evidence supporting a young Earth. But to be fair, let us examine a few of these and see why they are not convincing.

A few of the more popular evidences of a young Earth include the presence of short period comets, the slight thickness of dust on the Moon, a decaying magnetic field of the Earth, the discovery of radio halos in ancient rock layers, and a purported solution to Einstein's equations of general relativity allowing for a brief history of the Earth. This subset is chosen to suffice for a fair examination, since a pattern will be established from these that is consistently seen in other such evidences. Also, there are other sources the reader is referred to for a more extensive list of proposed young Earth evidences and responses to them (see [27] pp. 103-118, and [28]).

Short Period Comets

Short period comets appear to suggest that the solar system is only a few thousand years old, since comets actually burn away each time they pass close to the Sun, where they interact with the solar wind in producing the fiery tails we observe. They should eventually become burned out shells of dirty ice, void of further gases contributing to the bright dust and ion tails. Lifetimes of comets have been estimated to be no more than a hundred close passes to the Sun, before dying out. Therefore, the short period comets such as Halley's comet should all disappear within a few thousand years. Since we still observe many short period comets today, it is concluded that the solar system is only a few thousand years old.

The error in this reasoning is illustrated by a rare observation made in 1994, as we were treated to a spectacular astronomical show of a lifetime. We actually observed a comet crashing into a planet. Comet Shoemaker-Levi 9 was discovered the previous year, having a peculiar shape. Under high magnification telescopes it was clear that this comet was actually a collection of many smaller comet pieces. A larger comet had passed too close to Jupiter, whereupon the intense gravitational tug ripped it apart into over 20 visible pieces. The original orbit of the comet, heading towards the Sun, was radically changed in the process. Instead, the pieces were thrown into a highly elliptical orbit about Jupiter, which was calculated to bring them into a direct collision with Jupiter's surface. Several major telescopes around the world, include the Hubble Space Telescope, were directed at the comet trail as it collided with Jupiter in late July, 1994. We witnessed plumes of ejected material from the impacts several hundred kilometers in extent in a spectacular display of heavenly fireworks. This clearly showed us that comet orbits are not fixed forever. Most comets observed have long periods, such as the 1996 comets Hale-Bopp (2,380 years) and Hyakutake (14,000 years) [29]. But such comets do not always remain

in long period orbits, as Comet Shoemaker-Levi 9 clearly showed, since their orbits are disturbed by the gravitational tugs of the larger planets.

Long period comets can be altered into short period comets, but there is actually a much bigger supply of short period comets available. The Kuiper Belt is a ring of objects in the outer fringe of our solar system beyond the orbit of Neptune, which are now referred to as KBOs (Kuiper Belt Objects), of which over 500 have been identified [30]. The most recently discovered KBO, named Quaoah, has not only been observed but also measured to be over half as large as Pluto, the largest of the KBOs, even though it is still considered to be a planet. The KBOs remain largely undisturbed in the distant outer fringes of our solar system, unless a close encounter with another object sends one heading in, towards the inner solar system. It is only when it comes near to the Sun that it gains a distinct tail, generated by the solar wind hitting it. These become short period comets, with orbital periods of a couple hundred years or less. Otherwise, KBOs are very dim and very difficult to find. From the ones that have been identified there appears to be an ample source of short period comets for ages to come. Thus the presence of short period comets is not evidence of a young solar system.

The Thickness of Lunar Dust

In planning the Apollo 11 mission to land on the surface of the Moon in 1969, an important consideration was how much lunar dust would be encountered. In fact, estimates of dust accumulation both on the Earth and on the Moon had been made as early as 1960, using mountain measurements of nickel dust fall [31], which suggested that there may well be an extensive layer of Moon dust, as much as 145 feet. However, unmanned lunar probes did not see nearly this much dust. Finally, the Apollo 11 lunar lander, the Eagle, also did not get swallowed up by dust. In fact, only about two inches of Moon dust was found at the landing site, Mare Tranquillitatis, the Sea of Tranquility. This was then hailed as evidence for a young Moon [32], less than a few million years old, since several billion years of dust accumulation should have resulted in layer over 100 feet thick, based on the initial estimates of dust fall.

This evidence appears rather convincing from the outset. However it is fundamentally flawed at a primary input, namely the expected rate of dust accumulation. The original estimate of dust layering based on dust fall measurements on mountain areas did not distinguish between actual cosmic dust deposition and volcanic dust originating from the Earth itself. The latter actually dominated over the cosmic dust deposition, borne out by later more careful measurements made by satellites and high altitude flights. The present estimate for the amount of space dust falling to Earth per day is around 100 tons or an annual amount of around 36,000 tons [17], compared to the initial mountain based estimate of 14 million tons [31]. The smaller Moon should be accumulating less than half of this amount. When the correct rate of dust deposition is used for the Moon, we arrive at an expected thickness of approximately 1 inch. In fact, most of the thin powdery layer everywhere on the Moon, called the regolith, is primarily due to erosion caused by numerous meteor impacts.

While this may not impress some people, since it may appear to be “adjusted” after the fact to fit the observations, there are other considerations, which tell us clearly that the initial estimates of dust layering were grossly overblown. Dust contributes to the scattering of light coming from more distant sources and is much more effective in scattering blue light than red. A limit on the density of interplanetary dust can be estimated from the minimal amount of reddening seen using

the Hubble Space Telescope, orbiting just 320 miles above the surface of the Earth. The colors of planets seen by using appropriate filters with the Hubble Space Telescope yield images that match very nicely with pictures taken by probes we have sent to the outer planets, including the Voyager, Galileo, and Cassini missions. Our estimates of the interplanetary dust can also be estimated from the very dim reflection of sunlight after dusk, visible only for very dark skies, called the "zodiacal light". All of these considerations support the much lower rate of dust fall. We reach the conclusion that the thin layer of dust seen on the Moon does not indicate a young Moon. In fact, it is the expected thickness for a 4 billion year old Moon.

Decay of the Earth's Magnetic Field

A decaying magnetic field of the Earth has actually been determined by careful measurements of its strength over the last few centuries. At the present rate of decay, the magnetic field may actually go to zero in a few tens of thousands of years from now. This is potentially a dangerous problem for life on Earth, since the present magnetic field serves to deflect the powerful solar wind constantly bombarding the Earth. This would result in increased radiation exposure among other problems. Since the field appears to dying, one can attempt to extrapolate backwards in time to some plausible upper limit to the field strength to calculate an age for the Earth. As expected, such estimates lead to an age for the Earth no more than 10,000 years [33].

The magnetic field of the Earth has actually been continually oscillating in its orientation for as far back as the recorded magnetic patterns left in rocks can tell us. Approximately every 200 thousand years there is a complete flip in the magnetic poles of the Earth, so that magnetic north has been oscillating back and forth between the geographic north and south poles throughout the history recorded in deposited rock layers [24]. The strength of the Earth's magnetic field is measured by the amount of magnetic alignment measured in the rocks. The proposed upper limits on the Earth's magnetic field strength have never been approached during the oscillations of the poles. The rock layers can also be radiometric dated, so that we can determine when the magnetic north pole was near which geographic pole. The resulting magnetic field strength of the Earth appears to oscillating rather sinusoidally, not decaying exponentially. Therefore the extrapolation backwards in time used for the young Earth estimate is completely invalid.

What we have been able to learn by studying the history of the Earth's magnetic field, preserved in the magnetic alignment of older rocks has allowed us to determine the movement of continents over the surface of the Earth as well as the wanderings of the pole locations. The numerous pole flippings have apparently not had a disastrous effect upon life on Earth, although the increase in radiation levels would be expected. Although the magnetic field of the Earth is presently decreasing, we do not expect disastrous consequences any time soon. And once again, we are forced to accept that this observation does not imply a young Earth, since the magnetic field of the Earth has frequently been either increasing or decreasing during periods in the Earth's history for reasons that are not entirely clear. Although models of the magnetohydrodynamics of Earth's iron core show that pole reversals are expected, the cycle of pole flips is still something that present researchers are attempting to understand [34].

Radio Halos in Primordial Rock

The last two evidences for a young Earth we examine here are both highly technical, and for that reason difficult to actually decipher the validity of the claims being made. It is highly

unfortunate that these claims are being touted as some of the best evidences or supporting material for a young Earth, because very few people have the science background to judge their merits. For that very reason it is difficult to understand what the evidence really is, as well as possible flaws in them. However, scientists have carefully investigated these claims and found them to be lacking in several respects. I will try to express these in basic terms.

The discovery of radio halos by Oak Ridge laboratory scientist Robert Gentry was touted as a clear counterexample to the claims of antiquity made for the oldest primordial rock layers in the Earth. Such halos were claimed be formed from the decays of Polonium-218, which has a half-life of only 3 minutes. They can only form in hardened or crystallized rock. If such halos were found in the oldest rock layers, which as we've discussed in the last chapter required a long period of time to cool off sufficiently before solidifying, then how did the Polonium-218 get inside of the rock after it formed? Young Earth proponents claim this is clear evidence that God instantly formed the rock layers of the Earth [35].

To examine this evidence properly is difficult, since the discovery of various types of halos in rock is still being investigated. But attempts to verify the rock layers used by Gentry have been done. Geologist Jeffrey Richard Wakefield carefully examined the locations indicated by Gentry and concluded that each one was actually a younger infusion of igneous rock into the older primordial rock layers [36]. This alone invalidates the claim of evidence for a young Earth, since it would not have been difficult to obtain verification of the rock layers prior to publishing results. Other criticisms of this evidence deal with the production mechanism of the halos. At least one recently discovered mechanism involves a slow gradual process, favoring a much longer period of time in their development. The radioactive decay of Polonium-218 is not the only cause of the halos. But the bigger problem I see here is the attempt at using some complex phenomena, without the benefit of a more thorough investigation into its mechanisms, to support a particular age of the Earth. True evidence should only grow stronger under careful scrutiny, not weaker as in this case.

"Starlight and Time"

Finally, we consider a recent cosmological model claiming support for a young Earth, a model proposed by Gerald Humphries in 1996 in his book, "Starlight and Time" [37]. Although this is not an evidence of a younger Earth, this was nonetheless hailed as a great triumph for the young Earth enthusiasts. Prior to this development young Earth proponents had difficulty explaining why we observe light coming to us from billions of light-years away if the Earth and universe are in fact only a few thousands of years old. Earlier explanations involved claims of a slowing down of the speed of light (the "tired" light hypothesis) or that the universe really wasn't any bigger than around 10,000 light-years across. But since these claims were rather indefensible on scientific grounds (careful measurements of the speed of light reveal its constancy to a high degree of accuracy, better than one part in a billion [16]), a growing acceptance of this apparent age forced many young Earth proponents to adopt the "mature universe" idea, that God built an older appearance into the universe, just as He created Adam, the first man, as a mature adult. Thus the light was actually created in transit only a few thousand years ago, but never actually began its journey from the stars and galaxies depicted. One is then faced with the unavoidable consequence that most stars and all galaxies beyond the Milky Way seen in the telescope form a grand illusion of past ages.

This grand illusion was not very satisfying for all young Earth proponents, as is clear with the model proposed by Humphries. The model actually admits the antiquity of the universe, but attempts to preserve a young age for the Earth. His idea stems from a rather bizarre consequence of general relativity, that in very strong gravitational fields such as near the edge of a black hole (such a dense object that not even light can escape its gravity) clocks slow down compared to clocks further away from such strong fields. Actually this prediction of general relativity has been tested on a much smaller scale here on Earth through the slightly different rates (two parts in a thousand trillion) of clocks at the top and the bottom of a tower [38]. Although the gravitational field of the Earth is very weak compared to a black hole, the experimental procedure was accurate enough to reveal this very slight difference in rates. In like fashion but in a much grander scale, Humphries constructed his cosmological model to have time slow down drastically on Earth compared to the rest of the universe, just as is expected near a black hole.

The biggest problem with this proposal is that we see no evidence for such strong fields to have ever been present surrounding the Earth. Such would have resulted in much different clock rates than we observe between the clocks at the top and bottom of the tower. As one goes away from the Earth, there would be much greater differences in rates observed for similar processes. Orbits of planets would not be simply described by Kepler's deduced laws of planetary motion, rather distorted orbital periods would result. Going further out, stars would exhibit different rates in their life cycles. None of this is observed. But beyond the observational problems are the inherent problems of his model. While basing his model on general relativity in some ways, he ignores that general relativity requires that space and time be treated in a four-dimensional sense, while placing the Earth at the center of a 3-dimensional universe. Locating a present center to the universe is not possible in a 4-dimensional space-time universe, since the present visible universe lies on the surface of a 4-dimensional space-time sphere. Furthermore, the strong fields resulting in a radical slowing down of clocks are present only near enormous concentrations of mass, such a black hole. It appears from reading Humphries book that the model was not constructed to match observations of the physical universe, rather to match with his scriptural understanding.

Here lies the problem with Creation Science. It is not an attempt to understand the physical universe through application of basic laws and principles. Rather, it is an attempt to match science with a particular understanding of the Scriptures. While that may appear a worthy cause to some in the Christian faith, it is seen as just another example of pseudo-science to those who value a free and unfettered pursuit of scientific knowledge. Proponents of Creation Science defend the pursuit of scientific evidence to support a young Earth by claiming that evolutionary theory advocates are completely biased in their pursuit of supporting evidence and that science is never pursued without some ideological bias. Whether this is true or not, any bias a scientist may have will not allow him or her to escape the criteria for good science in the end. Creation Science evidences for a young Earth fail in these criteria. No evidence put forth for a young Earth has withstood the tests of both self-consistency and consistency with the observations. Just as the judge and jury would not be convinced by a lawyer's attempt to prove a recent death of a body when the coroner has found and presented overwhelming evidence for a long dead body, one who truly considers the evidence for the Earth's age will not be swayed by such proposed scientific evidences for a young Earth.

Chapter 4
Making Sense of it All

Allowing the evidence to speak for itself, we find the scientific evidence clearly favors an older Earth, approximately 4.6 billion years old. What are we to make of this? Will accepting the antiquity of the Earth invalidate the Christian faith? That is a bold claim being made by some. But that doesn't actually stand to reason or to careful examination of the Scriptures. Once again, as I risked discussing issues in chapter 1 that are not my areas of expertise, I am now willing to risk discussing how the scientific evidence for the age of the Earth relates to the Christian faith and the Bible. If people are willing to accept the scientific evidence, a common difficulty is then relating it to the claims of the Bible. I believe there are several important points to consider that are frequently overlooked in well-intentioned efforts to apply the Bible to questions such as the age of the Earth.

The Genesis Creation "Days"

First of all, contrary to the what is commonly held not only by young Earth proponents but also by many other people familiar with the Bible, extracting an age of the Earth from the Bible is not possible without assumptions and interpretations, some being quite questionable. Examine Genesis 1 with me. Certainly a straightforward reading of Genesis 1 reveals the central theme of God creating order from the chaos. Creation is described as having taken place during six days, during which different aspects of God's creative works are described. The climax of the story is the creation of man himself in the image of God. There are several unmistakable messages given in the account. There is a beginning to the universe and God is the cause of it. The incredible order we see in the universe is attributed to God's divine handiwork. Creation represents something very good and beautiful. Finally, man was created to have a special relationship with God. These messages do not conflict with the scientific evidence. Rather, the scientific evidence is supporting such an account, as described briefly in chapter 2.

But why is the creation account described as having taken place in six days, each of which is described by the words "and there was evening, and there was morning," the first (second, third, etc.) day? We could naturally assume that these days refer to 24-hour days. This would definitely imply a young Earth. But there are numerous problems with this assumption. The first problem is that a second account of creation is given in the following chapter that describes creation as having taken place in one day. It begins with Genesis 2:4, which states "This is the account of the heavens and the earth when they were created, in the day that the Lord God made the earth and heaven". How can both accounts be true? The problem is resolved by looking at the use of the word day in Hebrew, pronounced "yom". In some scriptural uses it clearly represents a 24-hour day, whereas in many other scriptural references it clearly represents unspecified or long time periods. This alone should force us to use caution when considering the time period in which creation took place.

A defense of interpreting the Genesis 1 days as 24-hour days, while keeping a figurative interpretation of the day used in Genesis 2:4, involves pointing out the manner in which the word is used. It is claimed that wherever this word is used with an ordinal adjective (first, second, etc) a 24-hour day is intended [39]. Since many Hebrew scholars have concurred with this, we should not lightly dismiss this. But let us think about it for a moment. The seven-day week is a

peculiar period of time, one not determined by astronomical means such as are the day (one Earth rotation), the month (one lunar cycle), and the year (one Earth revolution). The Genesis 1 creation account attributes the origin of the week to the precedent set by God himself with a cycle of six days of work, followed by one day of rest. This was given to mankind as a pattern to be followed. Beyond Genesis 1, all of the other uses of day with an ordinal adjective involve human activity. Thus it is not surprising that a 24-hour day is consistently implied. But should we use this to interpret the activity of God in Genesis 1, if humans do not appear until the sixth day? The uniqueness of the creation account makes this problematic. It should also force us to use caution in our interpretation of the word "day" in Genesis 1, as many Hebrew scholars have stressed [40, 41, 42].

Meaning Found in the Context of Creation

Thus exercising some caution, it may not be clear what precise time period is given by the creation account of Genesis 1. But that does not necessarily imply that the described days have no distinct meaning. There are additional considerations that actually favor an interpretation of these days different from 24-hour periods. Hebrew scholar Gerald Schroeder discusses the peculiar reference to each day: "and there was evening, and there was morning". If a 24-hour day was the intended meaning, why are the days described in such fashion? True, the Hebrew day is demarcated from sundown to sundown. However, the Genesis 1 days contrast evening and morning. Schroeder suggests that the meaning goes with the context of Genesis 1, namely, that God is transforming the chaos into order. Genesis 1, verse 2 describes the early Earth as "formless and void, and darkness was over the surface of the deep". Then God begins a remarkable sequence of creating order. Three days of separations are described (light from darkness, waters above from the waters below, and dry land from the waters below). Then God begins to populate the Earth with life. Since God is transforming the chaos into order, it is quite appropriate that each act be likened to the darkness of evening being transformed into the light of morning. Even the root meanings of the Hebrew words for evening, "erev", and morning, "boker", correspond to "disorderly" and "orderly" respectively [3, p 97]. This description is a beautiful illustration that any reader can relate to. Thus it appears that there really is no clear message of a precise time frame given by the "days" of Genesis 1. That simply wasn't one of the important messages being conveyed by the creation account.

You may wonder why the account is given sequentially, if a time frame is not being conveyed. There are some good reasons for this. The first three days appear to be rather distinct from the second three days. A theme of acts of separation takes place during the first three days, in which God is preparing the abodes of the things He plans to populate the abodes with. Then the second three days describe clearly what God places in each abode. This pattern would have been an easy one to remember in a day when oral traditions were much more common than written ones [43]. Also, the very fact that creation is described sequentially gives support to the premise that God used a process in preparing the Earth as a perfect abode for humans, since all of creation did not take place simultaneously. Although God is speaking all things into existence, the text does not describe what the process is. Thus we should not rule out natural processes acting over long time periods. Accepting natural processes as the means God used to accomplish creation does not question whether God could have created it all instantaneously or not. The sequential account shows us He clearly chose not to. For many individuals, it is even more awesome to consider how God could have used a vast period of preparation, involving so many different factors to work together just right, just for man to become the climax of all creation. As the

psalmist concluded, the vastness of our universe inspires an awesome sense of humility, whereupon accepting the creation account of Genesis inspires a tremendous sense of the value of human life (Psalm 8).

God's Time

To claim that Scripture is being re-interpreted to fit the latest results of science is not correct. Church fathers, including Augustine, did not interpret the creation days as 24-hour days [44]. Augustine noted that the seventh day of creation is not described in the manner "and there was evening, and there was morning", the seventh day. The Genesis account simply indicates that God "rested on the seventh day from all His work which he had done". The conclusion reached by Augustine is that the day of rest continues to the present, a conclusion also reached by many recent Hebrew scholars [40,41]. Although Augustine did not have the benefit of modern science to base his judgments on, he did appeal to reason in interpreting this account, something we should all do. In retrospect, from a modern scientific viewpoint, this conclusion appears to be confirmed, since we do not see any new acts of creation taking place, such as new species of life arising. We are witnessing only the extinction of many species in increasingly rapid fashion. God appears to be resting from his creative work.

In short, it doesn't appear that the Bible was intended to convey the age of the Earth in the creation account. In fact, the Bible seems to downplay the significance of time concerning the works of the Lord. Passages such as Psalm 90:4 "For a thousand years in thy sight are like yesterday when it passes by, or as a watch in the night", and II Peter 3:8 indicate that God's time frame may well be different from ours. And we note that He was the only one present during all of creation. Other writers have attempted to give some details concerning how the Genesis 1 days correspond to a history provided by a modern scientific account of the Earth and universe [27,45]. However interesting this might be, this very quickly requires some speculative measures that are difficult to firmly establish. Even with modern science it remains difficult to establish the time frame of the Genesis 1 days.

The Purpose of Scripture

While a precise time frame for creation may not be a clear message given by the Bible, there are many important ones that are. What is clear is that creation is the result of God's purpose and primary role. The vast order we find in the universe is attributed to God's careful handiwork. His meticulous care for detail in designing our universe is only becoming clearer with the increase in scientific evidence, as we discussed in the second chapter. Indeed, the more we learn of our universe, the more remarkably designed it appears to be. Proverbs 8:22-31 describes the creation events from the perspective of personified "wisdom", since the wonders of creation exhibit the unfathomable wisdom of our Creator. It seems reasonable to use the testimony of creation itself to learn about its age, if indeed that interests us. Expecting Scripture to give us an answer to this question is similar to asking Scripture to tell us the size of the visible universe, a question most people have no qualms about relegating to modern science, although they are closely related as we have seen. Although the Bible gives us truth, there are many questions it apparently does not give us the answers to. If it did, the important messages it does give would be inundated by unimportant ones. Concerning the scriptural account of creation, theologian Francis Schaeffer wrote:

> We are considering here matters which lie far in the past and concern cosmic events. That raises a question: Can we really talk in any meaningful sense at all about them? It is helpful, first, to distinguish between true communication and exhaustive communication. What we claim as Christians is that, when all of the facts are taken into consideration, the Bible gives us true knowledge although not exhaustive knowledge…. A Christian holding the strongest possible view of inspiration still does not claim exhaustive knowledge at any point. The Bible is a most efficient book. We must remember its purpose: It is God's message to fallen men. [42, p. 35]

Something that may still be troubling you is the question of when to interpret something literally or figuratively. At the risk of delving too far into an area that I am not an expert in, I will nevertheless make a suggestion for us to consider. In interpreting the days described in Genesis 1, is it "safer" just to accept the most literal interpretation? To answer this question, consider another expression that must be interpreted from the creation account. Three times in Genesis 1:26-27 it mentions that God made man in His own image. Yet in John 4:24, Jesus mentions that "God is Spirit, and those who worship Him must worship in spirit and truth." Clearly then, we must understand that being created in the image of God means that man was created with a spirit, in God's likeness. Insisting that man was created to physically "look" like God fails to accurately convey who God is. We must accept that the language being used in Genesis 1 is being used figuratively, lest we misunderstand it altogether. So it isn't always "safer" to accept a literal interpretation, if we are concerned with finding a correct one. Similarly, the figurative interpretation of the Genesis 1 days also makes sense, since it fits with the context of what is taking place in creation. Indeed, it has been estimated that over 150 figurative expressions are used in the first 11 chapters of Genesis [41, p. 88].

Understanding Scripture

A wrong understanding of God's Word can sometimes lead to tragic consequences. In Luke 4, we find that the people among whom Jesus grew up could not accept him as the Messiah. When asked to read the Scriptures, he read from Isaiah 61, "The Spirit of the Lord God is upon me, because He anointed me to preach the gospel to the poor". Upon completing the reading Jesus proclaimed to them "Today this Scripture has been fulfilled in your hearing", whereupon the Jews were filled with consternation, since they only recognized him as "Joseph's son". Instead of receiving the long awaited Messiah, they wanted to cast him off a cliff. Did they not know the Scriptures? Yes, they knew them well; the Scriptures were read every Sabbath Day in the synagogues. Did they not believe the Scriptures? Yes, they even had a special place reserved for the Messiah when He should come. Their understanding of Scripture did not permit them to consider that someone growing up in their midst could be the promised Messiah. Apparently, the ministry of John the Baptist had not prepared their hearts and minds to receive Him. They failed to learn from the miracles of Christ and they missed the main message. So we see that a prepared heart and an open mind to consider the evidence before us are essential.

Christians today have a much greater advantage in understanding the Scriptures, because Jesus sent the Holy Spirit to be our Helper in all matters concerning the faith. In John 16:13 Jesus said to his disciples "But when He, the Spirit of truth, comes, He will guide you into all the truth...". We need not wrestle with these issues hopelessly by ourselves. God Himself can give us a peace and assurance that we are on the right track, or some gentle nudges that we have strayed from the truth. I urge all Christians to consider the issue of the age of the Earth prayerfully. I've merely

given you some input from science and the Scriptures, to encourage reason in your considerations. A Christian needs to ask God for guidance on all issues that are considered important to the faith. Many Christians have concluded as I have, that the age of the Earth is not an important issue of the Christian faith, since the Bible places no importance on it. The prayer that Jesus lifted up to the Father in John 17 stressed the unity that Christ so much wanted for his followers, a unity not to be broken by minor doctrinal issues of the faith.

Accepting the Evidence

Finally, we come back to the root cause of the whole controversy. Will accepting an older Earth be like "giving in" to arguments supporting Darwinism? No, that doesn't logically follow either. Although Darwin and his supporters sought evidence for an older Earth to support the theory of evolution, the finding of such evidence does not necessarily lend credence to his theory. Time does not necessarily make some things probable. In fact, many experts researching the probability of random ordering of biological molecules have concluded that this is extremely remote, even in 14 billion years of time [46]. As a physicist, I see some very convincing evidence for the antiquity of the Earth, but a plausible theory of naturalistic explanations for the origin of life has yet to emerge. We see a vastly complex order in the genetic code of even the very simplest life forms. We are just beginning to understand this complexity while we piece together the human genome. I find this fascinating, and I welcome what we will find. New scientific understanding of origins, whether it be origins of the universe, our galaxy, our solar system, the Earth, or life on Earth, do not pose a threat to the reliability of the Bible. Judging from previous experience, it promises to provide even more convincing evidence of God's remarkable design, built into the universe at every level.

We see that the Christian faith is not imperiled by an acceptance of an old age for the Earth. The truth of God's Word may be accepted on the basis of a very reasonable faith, one that has a healthy respect for science as well. Recently discovered scientific evidence is in fact, supporting the clear messages of the Bible. Although science tends to change with new observations, a clearer understanding of our physical universe is developing. We are growing increasingly more confident in the evidence that points to what has taken place in the past. A clearer picture is emerging. And the clearer it becomes, the more it appears to agree with the Biblical account of creation. Evidence for meticulous design built into the very fabric of our universe, including the ordered laws and fine-tuned balance of properties necessary for our existence, is convincing people of God's handiwork. Psalm 19:1, "The heavens declare the glory of God; and their expanse is declaring the work of His hands", is being fulfilled.

I haven't given you all the answers to questions you may have. I certainly don't have them all. But I have given you some things to think about and prayerfully consider. Rather than reject the testimony given by the scientific evidence, why not embrace it and allow it to strengthen your faith in the truth of God's Word? If you are a Christian, and this has not agreed with your understanding of God's Word, please consider the points made in this chapter. It is a liberating feeling to find that science is providing a testimony consistent with God's Word. The account of creation in Genesis has some very clear and profound messages that our world needs to hear. But have we learned to appreciate these and integrate them into a worldview that welcomes knowledge from various disciples of study, including science? Until we are willing to examine both, we won't be able to see the beautifully consistent fit that is becoming clearer.

And if you are one who appreciates science, but have been hesitant to accept the Bible, consider what may be holding you back. Is it really still a question of the Bible's validity, or is it what such an acceptance would mean for you personally? Yes, the Bible reveals that you must make a major commitment, one involving your entire being. That's the only way God intended to have fellowship with us, with our entire lives opened up to him. Jesus paid the penalty for our sins, but we must receive Him as Lord and Savior, by inviting Him into our lives (Romans 10:9). Since you've read this far, I trust you recognize that the scientific evidence is pointing to the truth of the Bible. It's time to make a personal commitment, since God didn't provide all of this testimony for an uninvolved observer. Seeing the testimony requires a personal response, just as the writer of Psalm 19 concluded. I hope and pray that you choose to open your heart to Christ. The beauty of seeing science and the Bible provide consistent messages does not compare to the beauty of knowing Christ.

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