INTRODUCTION

What is "The Science of How We Got Here"?

Whether stuck in traffic or surfing the internet, most of us are so immersed in present-day civilization that we never stop to reflect on how incredible it is that human civilization exists on this blue-green paradise we call Earth, a planet that teems with life and circles a benevolent star in a quiet neighborhood of the Milky Way galaxy. How *did* we get here?

People were asking this question long before anyone knew what planets and stars and galaxies were. We have always needed to know how the world was made and how people came to be. For tens of thousands of years we relied on creation stories to answer these existential questions, to make sense of a frightening world, and to explain the meaning and purpose of human life. In the ancient Babylonian story, the world was created by Marduk who was himself the son of gods, and Marduk created humans to labor in the world and to worship the gods—this was the purpose of human life. For the Hopi people of the American southwest, there was in the beginning only the Creator, Taiowa, who made Sotuknang and entrusted him with making the nine solid worlds that included Earth and its people. And the Old Testament Bible says that God created the Earth and its people in six days and that he made people in his own image.

Cultural creation stories such as these have deeply satisfied people for eons with explanations of the origins and meaning of life. The many different stories and beliefs that can be found worldwide demonstrate the great variety of cultures in our world. While some creation stories share common themes from culture to culture, there has never been one story shared by all the people of the world. Today, however, nearly all of humanity shares the methods and products of science. We rely heavily on science for our explanations and answers. After all, it has brought tremendous power and prosperity to people everywhere, ranging from nuclear weapons and mobile phones, to artificial limbs, cures for deadly diseases, and the internet. We have arrived at a juncture in time where we have the exciting opportunity to explore the ancient question of how we got here from the *scientific perspective*—a perspective that people everywhere can choose to share, as science has become a universal language in today's world.

As recently as the mid-twentieth century, science could do very little to explain how we got here. It could not explain what life is, or how it got started on Earth; it could not account for how and when the Earth and Sun were made; it had no theory of how the universe itself was born and how stars and elements and planets are created; and it could not say how long humans have been on Earth and what they were doing for most of that

time. For most of the last 300 years, science could only tell us that we were tiny, insignificant specks in a virtually infinite universe. And modern people have been increasingly disconnected from nature, with little sense of place or purpose in the universe.

However, in the later twentieth century, spectacular discoveries in many fields of science, particularly molecular biology, astrophysics, and paleoanthropology, made it possible for the first time to seriously consider our origins. The dazzling pace of scientific discovery has continued unabated into the twenty-first century, and now a new kind of creation story is emerging for humankind—one that springs entirely from the evidence and skepticism of science.

In 2005, after a 30-year career as a classroom science educator, I began the project of finding the creation story according to science. I wondered how well science could account for the existence of human civilization on Earth, and I wanted to learn and know the science behind the story. So I set out in search of the science of how we got here, of how the universe was born and how it produced a Sun and Earth, how life began and slowly turned into upright-walking creatures with very large brains, how these *Homo sapiens* developed technology and language and eventually spread over the entire Earth, and how human civilization finally emerged. This book is the result of my search.

Journey to Civilization is not just the story of how we got here, but also an exploration of the science behind the story, and how we know that science. To understand this story we must journey through many fields of modern science including astrophysics and cosmology, evolutionary biology, molecular genetics, and paleoanthropology. Explanations are written for the curious *non-scientist*, yet some readers may tend to feel overwhelmed or intimidated by new terms and technical-sounding jargon. But please be assured, however, that you do not have to master every concept and term before you can move ahead with the story. Simply soak it in, revel in the depth and richness of human knowledge, and marvel at what we have achieved. In the end I hope you will change your view of humanity.

Dealing with Time

The story of how we got here is set in time, and time presents many challenges as we try to understand it. Even without considering the more baffling aspects of time that Einstein discovered, such as the warping of time in strong gravity, we will find that simply comprehending the time scales in the history of life and the history of the universe is very difficult.

To illustrate this, consider these four time spans that are of major importance in our story:

5000 years – the length of time civilization has existed.

200,000 years – the length of time humans (*Homo sapiens*) have existed.

4.55 billion years – the length of time the Earth has existed.

13.75 billion years – the length of time the universe has existed.

It is very difficult to grasp these time spans, even the shortest one. "History," in the traditional sense, goes back only about 5000 years to the first civilizations of Sumeria when writing was invented, and until recently everything before that has been called "prehistoric." It is just about all we can do to imagine how long ago it was that the Romans lived, and the Greeks before that, and the Egyptians before that, but this takes us back only about 4,000 years. To understand our deepest history—the origins of humanity, and the history of life, the Earth, and the universe—requires a completely different view of time that is often called *geologic time*. Geologic time, with its *hundreds of millions* of years and *billions* of years, is so vast and deep that no one can really comprehend it. Yet we will need to deal with it.

Another problem with time is the *relative size* of the different time spans we will be talking about. For example, how does the 5000-year history of civilization compare to the 13.75 billion-year history of the universe? One way to convey the answer is to say that if we used the distance of *one mile* to represent the age of the universe, then the age of civilization would be only about *half a millimeter*, or the thickness of a few sheets of paper. Put another way, it's like the thickness of a human hair on a 100-meter football field. You cannot look at both things at the same time. Yet this is what we will be trying to do.

To help with these problems, we will use a *geocosmic timeline* like the one shown on page 5. This timeline divides the 13.75 billion-year life of the universe into three equal intervals—we will call these the three *geocosmic days*. A geocosmic day is simply the length of the time that the Earth has existed, and we know (as of 2003) that the universe is just about exactly three times as old as the Earth. The idea of the geocosmic day is not so different from the other natural time units we use:

One day = the amount of time it takes for the Earth to rotate once on its axis.

One year = the time it takes for the Earth to circle the Sun.

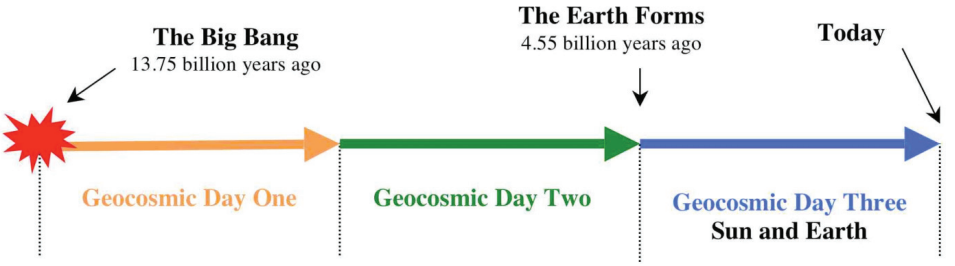
One geocosmic day = the amount of time the Earth has existed; that is, the age of the Earth.

Using the geocosmic day as a unit of time will be helpful in several ways. First, we get a better understanding of how old the universe is when we think of its life as filling <u>three</u> *geocosmic days*. This means that the universe is almost exactly three times as old as the Earth. Most of the life of the universe (*two-thirds* of it) occurred *before* the Sun and Earth even existed! Secondly, because most of the action in our creation story takes place on the Earth, filling only the third geocosmic day, clock times during that third day will help give us a better time perspective on important events. For example we can say that the beginning of life on Earth, roughly 3.8 billion years ago, happened at about 4:15 in the morning of the third geocosmic day; that dinosaurs went extinct at about 11:40 pm (at night!) on that last day, and humans finally showed up at about 11:59:56 pm—just 4 seconds before midnight. A more complete listing of important

events in the creation story is given next page. As we move through billions of years in the next twelve chapters, we will often represent the life of the universe in three geocosmic days. This helps us get a handle on time and the vast time scales of our story.

This book is structured in five parts, representing five great ages in the story of the universe. Part One covers the first two-thirds of the life of the universe, the time before the Sun and Earth existed, from the birth of the universe, through the emergence of stars and galaxies, to the formation of the Sun and Earth. Parts Two and Three tell the story of life on Earth, from its mysterious origins to the age of large mammals and primates. Parts Four and Five explore the labyrinthine saga of the hominid lineage, from the development of upright walking, to the appearance of *Australopithecus* and *Homo*, the emergence of humanity, and finally civilization.

If we look at the geocosmic time scale representing the life of the universe and the list of events next page, it is clear that we humans are a very, very recent arrival. The entire hominid lineage, going back about 7 million years, fills only the last two minutes of the third geocosmic day in the life of the universe. Modern humans do not show up until about 4 seconds before midnight (which represents now), and civilization finally kicks-in at 11:59:59.9 pm—one-tenth of a second before midnight! That is to say, the entire field of traditional western history—going back 5000 years to the first city states in Sumeria, then Egypt, Greece, Rome, and Europe—would fill only the last *one-tenth of a second* in the three-day life of the universe. Until recently we knew almost nothing about the rest of that time, before the first civilizations. But now, our discoveries and growing knowledge in many fields of science make it possible to tell the whole story, the big story, of how we got here, from the very beginning. We better get started.



A Geocosmic Timeline of the Universe
Here the life of the universe is depicted in three geocosmic days.
One geocosmic day equals 4.55 billion years, which is the age of Earth.

Main Events in the Story of the Universe
(All dates are approximate)

Event	Actual Years Ago	Geocosmic Time*
The Big Bang	13.75 billion	Day One, 12:00 am (midnight)
The first stars	13.3 billion	Day One, 2:00 am
The Milky Way Galaxy forms	12.7 billion	Day One, 5:15 am
Dark energy begins to dominate	7.5 billion	Day Two, 8:00 am
Formation of the Earth	4.55 billion	Day Three, 12:00 am (midnight)
Life begins	3.8 billion	Day Three, 4:15 am
First complex cells (eukaryotes)	2.4 billion	Day Three, 11:15 am
The Cambrian explosion of life	540 million	Day Three, 9:00 pm
Age of the dinosaurs	240-65 million	Day Three, 10:40-11:40 pm
First human-like ancestors (genus *Homo*)	2.5 million	Day Three, 11:59 pm
First anatomically modern humans	200,000	Day Three, 11:59:56 pm
Civilization begins	5,200	Day Three, 11:59:59.9 pm
Today	0	Midnight

**One second of geocosmic time = 52,800 years of real Earth time*