

Proposal for a Book

The Meaningful Universe

Our Pivotal Place in the Cosmos

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INTRODUCTION

Every culture that anthropologists have studied had a mental picture of a larger reality that gave their lives meaning and purpose. This understanding of the universe determined the imagery built into their languages, their beliefs about the gods, their intuition about what was possible, and the tenor of their lives. Within this picture of reality, constructed in the mind through a lifetime of stories and rituals, the world and the place of human beings within it made sense. This kind of picture anthropologists call a “cosmology,” which literally means “to speak about the order of things.” When 17th century science began to demand what no culture’s cosmology had ever possessed – scientific evidence – no tradition could pass the test. Neither could any scientific theory. Since Galileo’s telescope overthrew the geocentric picture, we have not lived in an agreed-upon universe. It is normal today to have no sense of what the universe might be. Does time run in one direction or is it cyclical? Has the universe always existed or did it come into being? If it had a beginning, how did it start? What is it really made of? How do we fit in? Human beings seem to possess a need deeper than the demands of any given culture to understand such things, but for the last few centuries we have had no way to do so. We might feel as though we are living a too small, frantic life, without gut-satisfying meaning, in the face of frightening, global problems that seem to have no solution. Like a colorblind person who never sees gaps in the scene before him, we can’t tell what is missing.

In the introduction we explain that for the first time in history it is possible not only to begin to answer these questions scientifically but also to visualize our entire evolving universe. New kinds of telescopes and other instruments are for the first time gathering data from the most distant reaches of the universe. A theory of the universe as a whole based on scientific evidence, is now emerging – a theory that explains how the universe operates, what it’s made of, where it may have come from and how it is evolving.

Unlike earlier stories, modern cosmological theories are mathematical. Although they are based on relativity and quantum physics, they can be translated into more accessible languages. With a mental picture, it becomes possible to think on the scale of the universe and begin to experience the kinship that earlier cultures felt with the universes they envisioned. The aim of this book is to help you the reader to understand the expanding universe and experience your place in it both intellectually and intuitively.

Any modern “picture” of the universe must be symbolic, because we can’t see the universe directly: almost everything in the universe is invisible to humans; we can never step outside the universe to view it; and no view of any amount of it could capture all of time as well as space.

This book interprets today’s best theories of the origin and nature of the universe visually, using a series of symbols. Unlike a logical argument, a symbol can be held in the mind all at once. We don’t have to stop and think about a word after we know it – we just glance at it and know its meaning. That is the power of symbols. In this book each symbol encapsulates a single deep insight about the universe, but none alone can represent the universe. Contemplating these symbols is a further way to help the ideas within them to “soak in,” rather than remain isolated abstractions.

For a millennium before Galileo, earth was the center of the universe. Afterward, space has seemed so unimaginably large and vague that there has been no basis for feeling central or even important to the cosmos. From the picture of the modern expanding universe emerging today, however, a great truth appears: human beings are actually central in several important ways. For one, we are made of the rarest stuff in the universe: stardust. For another, we creatures of one to two meters in height stand midway in size between the horizon of the visible universe and the smallest size permitted by relativity and quantum theory, as we will show. Thirdly, we are living at the midpoint of time.

“The midpoint of time” is a strange phrase but actually meaningful. Scientists confirmed in 1998 that the expansion of the universe, which for many billions of years had been slowing down because of gravity, has in the last few billion years begun accelerating. Gravity has been fighting against expansion since the Big Bang, and in denser regions it has won and created stable structures like solar systems and galaxies, which are bound together gravitationally and do not expand. But on larger scales where the universe is less dense, expansion is winning over gravity. Any cluster of matter that hasn’t already collapsed together because of gravity, never will. Our galaxy, the Milky Way, is a hundred billion stars bound to sail together forever in the expansion of the universe. Other galaxies and even many galaxy clusters are also held together by gravity, but the largest structures in the universe, called superclusters of galaxies, are not bound. The expansion is dispersing them. At the present time in cosmic history, just when human science has acquired the ability to see to the distant reaches of the universe, the accelerating expansion is causing the most distant galaxies to be carried away by more rapidly expanding space and to disappear ever faster beyond the cosmic horizon. In short, the visible universe is emptying out. Our distant descendants, no matter how advanced their telescopes may be, will never be able to see as many galaxies as we can now. In this sense, we are at the midpoint of time.

We also live at the midpoint in the life of the solar system. Our sun and its planets are about five billion years old. Like other middle-aged stars, the sun has been growing steadily hotter. It has about six billion years to go until it becomes a red giant and expands to swallow the planets Mercury and Venus and burn earth to a crisp.

Meanwhile on earth our generation stands at another turning point in time, but a much more pressing one. Burgeoning numbers of people are squeezing out all other large animals on earth except those we grow for food or keep as pets. We fight each other for control of diminishing resources, with no globally agreed-upon method to deal with our differences. It is still possible that we humans will halt our deadly slide toward species extinction, environmental degradation, and violence. This possibility may only be available for a relatively brief time longer. Our technological power and resource use are growing exponentially. Exponential growth in a finite environment must always stop sooner or later. The Big Bang itself now appears to have been the abrupt end of an exponential growth called “cosmic inflation,” as we will explain, and the Big Bang has been followed by slow and stable expansion for billions of years. However, that stable expansion was structured during the last moment before the Big Bang, when cosmic inflation created the blueprint for the entire future evolution of the universe. If the universe is a model for earth, then the current period – the last moments of inflationary

growth on earth – may set the pattern for the very long-term future of the planet. This means political decisions made today could have far more lasting impact than common sense can imagine. The time scale is not precise. If it is a century or a decade, it's a fleeting instant by cosmic standards.

The growing number of people multiplied by the growing impact of each one on the environment and on each other will reach a peak from which we must either crash or else be brought rapidly to a sustainable level of consumption – through some creative means. An essential ingredient of that kind of creativity may be a cosmic perspective, and for the first time it is available. Not a moment too soon.

Part I SPECULATIVE FACTS AND BELIEVABLE FICTIONS

Chapter 1 The Cosmological Revolution *Encompassing, not Overthrowing*

How seriously should we take the new cosmological story? Sometimes it doesn't feel worthwhile to learn what science is telling us today, since it seems next month it will be telling us something else. Health pronouncements, for example, can be fickle and frustrating, but that is often because people are trying to infer too much from a single experiment or study.

But science does not change at all quickly with respect to its foundational theories, which is what cosmology is creating today. Like physics after Newton or biology after Darwin, cosmology is for the first time undergoing a transformation from a loose collection of uncertain observations and speculative ideas to a discipline with reliable data organized by an overarching theory that ties everything together. This is a scientific revolution of the kind that typically happens only once in the development of any branch of science, and the vision emerging now will forever influence how we think about the cosmos and how we interpret all observations.

Cosmology is not a laboratory science, based on experiments. It is one of the “historical sciences”— a category that includes geology, evolutionary biology, paleontology, and archaeology. In all these scientific fields where we re-construct history, scientific predictions are not about what will happen but about what we will discover about what already happened. Cosmology is also concerned with the future, but we can only trust predictions about the future of the universe if our scientific understanding of how the universe evolved in the past is repeatedly confirmed by observations with our constantly improving instruments.

In cosmology we observe nothing more than photons of light, or the shower of more exotic particles, impinging on our instruments. In recent years, cosmologists have succeeded in constructing a theory that has been making consistently successful predictions. Light and other cosmic rays are the carriers and preservers of history in the universe. As we learn to read their messages, we learn what the universe is – its overall scope and its sometimes counterintuitive nature. The theories of modern cosmology are derived and expressed mathematically, and there is no single right way to interpret mathematical statements in words. Scientific research is often described as “putting together the pieces of a jigsaw puzzle,” but at least in cosmology this image is misleading

because there is no pre-existing picture. As more pieces of data are juxtaposed in a kind of intellectual collage, a picture of the expanding universe is created collectively on a larger scale than any individual's imagination. Before exploring this new science-based cosmology, we must understand the nature and importance of cosmologies for people throughout history.

Chapter 2 What Is a Picture of the Universe? *Ancient Images of the Great Beyond*

Ancient cosmologies developed powerful imagery that can help us to express symbolically our connection to the modern universe. In this chapter, we review several examples of how cosmologies functioned in the past. The powerful symbols they developed may still be useful in creating a functional, science-based cosmology today. Long-lasting cosmologies, like the Biblical creation stories, are successful because they emotionally link people to a larger reality. This book adapts some of the imagery popular in cosmologies around the world as building blocks of a new cosmology.

Origin myths are a large part of a cosmology, and they help set the picture people hold of their universe. If taken literally, all origin myths have been wrong. But few were intended as literal descriptions of a world independent of human beings, the way modern cosmology approaches the Big Bang. They were actually about the connection between people and the world and were often intended symbolically. Origin myths have generally been narratives involving mythic characters, sometimes gods or ancestors or totem animals, whose actions created the world, in settings that typically resembled – and thus gave cosmic meaning to – local geographical features. To the modern ear they seem quaint and fanciful, but they should not be so easily written off. These narratives constructed a conceptual framework that allowed people to understand themselves as part of a far larger drama still playing behind the scenes of everyday life – both influencing and giving value to that life.

Shamanic, earth-based cosmologies have existed for tens of thousands of years. Shamanic peoples visualize sacredness in animals and in mountains, rivers, and caves, seeing them as ancestors or gods, in order to experience themselves as deeply bonded with the natural world. This helps them to draw on greater powers to enhance their own effectiveness as human beings. Historically, one of the most common symbolic images they used for the universe, or for ultimate reality as they understood it, was a serpent swallowing its tail, suggestive of unity or endless cycles.

Highly developed cosmologies based on a “flat earth” picture existed in ancient Sumer, Egypt, and descendant cultures like that of Babylon. A flat earth picture was also held by the ancient Hebrews, easily surviving the change from polytheism to monotheism. When the ancient Hebrews were writing the stories in Genesis, their picture of the universe was a flat earth beneath a domed sky. Before creation the spirit of God hovered over “the deep.” After creating light on the first day, God on the second day “divided the waters” – an idea that only makes sense in a flat earth picture – that is, He took “the deep” and made a space for His creation in the middle of it by dividing it into the water above, which made the sky blue and which God held up with an invisible dome (called “the Firmament” in the King James translation), and the water below. It was

inside this bubble that the Hebrews understood God to have created the new (flat) earth and its inhabitants. The Genesis creation stories continued to be read and told, but the mental image of a flat earth gave way among educated people to the Greek picture of a round earth, which accounted fairly well for astronomical observations. Throughout the medieval period, Christians, Moslems and Jews alike interpreted the Genesis stories with minds that visualized “the creation” as the Greek universe — a spherical earth, eternally at the center of nesting celestial spheres carrying Mercury, Venus, the sun, the moon, Mars, Jupiter, and Saturn. These were sometimes called the seven heavens, and God sat just beyond the last sphere. In this way the monotheistic God of Genesis was smoothly integrated into the pagan geometrical picture.

Some medieval Jews, called Kabbalists, developed their own story of creation (that is, creation of the spherical earth and the spheres) by presenting a picture in which the universe began in a point and expanded. The way they explained it, God, who was everywhere, had to make space for creation. He chose to withdraw into Himself from a special point that contained all wisdom, thus making room inside Himself for the point to expand and become the world. But God was now in exile from the world. Jews, who had been thrown out of nearly every country in Europe, thus created a cosmology of exile, which gave a cosmic meaning to their lives.

Meanwhile in Christian Europe, the Catholic Church and the divine right of kings reflected a cosmology of absolute, eternal stability, represented by the divinely created hierarchy of the spheres, with the human hierarchy on earth of church, state, and the patriarchal family. The medieval cultural synthesis of a monotheistic God and a pagan picture took a thousand years to perfect, and its destruction in the 17th century by the discoveries of Tycho Brahe, Galileo, Kepler, and Newton left a gap in Western culture that has never been filled.

Four centuries later, we have entered the golden age of scientific cosmology: for the first time we are able to gather data from the entire visible universe and we are constructing the first universe picture ever supported by scientific evidence. But unlike pre-scientific pictures, this picture says nothing about the role of humans or about anything sacred in the universe. This is why to many people these discoveries do not yet matter. Before the new cosmology will ever become important to the great majority of people, the connection between the expanding universe and us must be made – not definitively but suggestively, always leaving room for other interpretations but setting a minimum standard. Humans need not only science but a story. We need to derive inspiration from the universe in order to appreciate the value of our connections to it. The way shamanic peoples use imagery in stories and rituals to conceptualize and magnify their connection with nature may suggest ways completely consistent with science to *appreciate* our central place in the expanding universe.

Scientific cosmology cannot be understood or discussed without some key concepts, which we explain and depict symbolically in the next four chapters.

Part II PICTURING THE EXPANDING UNIVERSE

Chapter 3 What Is the Universe Made of? *The Cosmic Density Pyramid*

Human beings are made of the rarest stuff in the universe: stardust, created deep inside massive stars, and then spewed out in gigantic stellar explosions.

What we think of as “ordinary matter” – basically, everything made of atoms more complicated than hydrogen and helium – is not ordinary at all. Everything we see – the stars, gas, comets, dust, and planets – is only about half a percent of all that’s out there. The rest of the atomic matter in the universe totals only about 4%, and the vast majority of it is invisible. This invisible 4% is probably mostly a dilute plasma of the two simplest elements, hydrogen and helium.

What’s the rest? The two major ingredients in the cosmic recipe for density were unknown until late in the twentieth century. Almost a third of the whole is non-atomic “dark matter,” an invisible, not-yet-detected substance whose immense gravity holds the spinning galaxies together. Almost two thirds seems to be an even stranger stuff called by Einstein the “cosmological constant,” or more generally referred to as “dark energy.” Dark energy causes space to repel itself, speeding up the expansion of the universe. But dark energy also adds to the density of the universe, since as Einstein showed, energy and matter are closely related.

Until a few billion years ago, the gravitational attraction of the dark matter continually slowed the expansion of the universe. But billions of years of expansion caused the dark matter to thin out, while dark energy is effectively a property of space and doesn’t thin out as space expands. The more space, the more dark energy. So now the dark energy has surpassed dark matter as the dominant force in the universe and expansion is no longer slowing down but instead accelerating.

What is the non-atomic dark matter made of? No one yet knows. But Joel and a colleague proposed in 1982 what remains probably the most popular idea among physicists – supersymmetric weakly interacting massive particles (WIMPs). These particles are being searched for in deep underground experiments, in space, and at the biggest accelerators.

Stardust is the main thing our planet and all its living beings are made of. Even water is mostly made of stardust. Oxygen, like other medium-sized atoms, is forged in the nuclear furnaces at the centers of massive red giant stars. Except for hydrogen, which is about a tenth of your weight, every atom of your body was made in stars. We stardust beings are rare jewels of the universe, and this is a fundamental truth, not human wishful thinking.

We can symbolize our place among the universe’s ingredients with the pyramid topped by the all-seeing eye, a Masonic symbol on the Great Seal of the United States, which appears on the back of every dollar bill (see illustration.) We let the pyramid on the dollar bill represent all the visible matter in the universe – this was what people used to think was all that existed. But there is a hidden base beneath this pyramid that extends down as far as the visible pyramid extends upward, becoming much more massive as the pyramid spreads out. This base represents the invisible 90% of all atomic matter. But now we know that both the visible pyramid and this heavy, hidden base are together

merely the tiny tip of a massive ghostly iceberg of dark matter and dark energy. This entire iceberg we call the Cosmic Density Pyramid.

Here again, we humans find ourselves in an unexpected sense “special” in the cosmos. As it says on a flowing ribbon below the pyramid on the dollar bill, this is the “New Order of the World.”

Chapter 4 Where Is the Center of the Universe? *The Cosmic Spheres of Time*

Thanks to Galileo, we no longer believe that earth is the center of the universe. But it turns out that our galaxy is the center of the visible universe, because every galaxy is the center of its own cosmic horizon. Let us explain this surprising and intriguing discovery.

People naturally wonder where the Big Bang happened. The answer is that it happened *everywhere*. Asking “where” assumes there was some pre-existing space in which a location can be defined, but one of the most counterintuitive ideas of cosmology is that the Big Bang created space and time. Before there was space, there was no “where.” Space is not, despite common English usage, just the emptiness in which things happen: according to relativity space is a dynamic medium with its own wrinkly structure. The Big Bang created the possibility of “where,” and all “wheres” are inside the Big Bang.

Because light travels at a finite speed, no one – neither we nor aliens on any world, no matter how advanced they might be – can see farther than light can have traveled in the age of the universe. That age is about 14 billion years. This creates a horizon, a distance beyond which we cannot see, not because of technological limitations but limitations in principle. Every star or galaxy we observe today, we see as it was when the light reaching us left it, whether that was a thousand or a billion years ago. Thus when we look out into space, we are looking back in time.

The universe is expanding. Space itself is stretching between distant galaxies and galaxy clusters, carrying them farther and farther apart. Space is infinitely elastic – it could stretch forever – and the expansion of space is indifferent to the speed limit of light. Space expands uniformly. It carries objects away faster the farther they are from us simply because there is more expanding space between us and them. About fourteen billion light years away space is expanding at the speed of light and no light coming from beyond that distance can reach us.

In the medieval universe, God enveloped and cradled the whole structure of nested crystal spheres. People looked into the sky as if they were looking up to the ceiling of a great cathedral with God just outside. Their beliefs about God’s will, their acceptance of social position as fate, and their understanding of church and state as reflecting divine authority on earth, were all modeled on this hierarchical picture of the heavens. The picture seemed unquestionable because it reflected the feeling of centrality every person has not only toward the universe but toward every object and person around us. We all see ourselves as the center of our own perspective on the universe. This is the nature of human consciousness.

A new symbolic picture of concentric spheres can communicate all these ideas: the limiting speed of light, the concept that looking out in space is looking back in time, the evolution of the universe, and the human to human resonance of ideas across the ages. Remarkably, in modern cosmology we are central in a sense never imagined in the

Middle Ages. We can reinterpret the medieval picture in light of what we now know – that we are at the center of our cosmic horizon. We can accurately say that we are surrounded by nesting spheres, but they are Cosmic Spheres of Time. The spheres need to be understood as representing successive epochs in the evolution of the universe since the Big Bang. In the Cosmic Spheres of Time, our galaxy is the center of the visible universe. The innermost sphere around us contains the most recent past, and the nearest stars and galaxies. The farther away from us a sphere is, the farther back in time are the objects we are seeing in that sphere. The most distant sphere represents the Big Bang.

Every galaxy moving with the uniformly expanding universe is at the center of its own Cosmic Spheres of Time. The symbol of nesting spheres in this new interpretation represents two profound truths: the interrelationship of time and space, and the interdependence of human consciousness and the visible universe. In the Middle Ages the phrase “As Above, So Below” became a justification of the supposedly eternal, God-designed nature of repressive social hierarchies, but in our new interpretation it is clear that every viewer is ultimately his or her own center and is not above or below any other.

Chapter 5 How Big Is the Universe? *The Cosmic Uroboros*

Human beings are at the center of all possible sizes in the universe, and complex consciousness like ours could only exist in creatures of a size very close to our own.

In physics, not all sizes are possible: there is a smallest and a largest size. The one or two meter height of a human being is midway between them, and humans could not be any other size. Complex consciousness can only exist where there are enough atoms for enormous complexity, packaged in a region so tiny that communication is extremely rapid. The human brain fits the bill. A consciousness as large as a galaxy could only have had a few thoughts in the history of the universe, since it takes light 100,000 years to cross the galaxy.

Why are some sizes impossible? Objects can only exist if they are made of a certain amount of stuff packed into a certain size region. General relativity predicts that if any region gets more than the maximum amount of mass for its size, the region will collapse into a black hole of no size at all, even though its gravity is still there.

Meanwhile, the uncertainty principle of quantum mechanics says that the smaller the region in which an elementary particle is confined, the more energy is required to find it.

Taking these two theories together, there turns out to be one special size – and this sets the smallest size possible – where the most mass that can be crammed into the region is also the smallest mass that can be confined in so tiny a region. A particle with less mass would have to be “bigger” in the sense of allowing more uncertainty about its exact location. How small is the smallest size? Take a centimeter, take a tenth of it and a tenth of that, repeat 33 times, and what’s left is 10^{-33} cm – the smallest size that makes any sense to talk about, given our current understanding of physics. The largest size we can know is the horizon of the visible universe, about 10^{28} centimeters in radius. Between the largest and smallest sizes lie about 60 orders of magnitude: a 1 with 60 zeroes following it – huge, but measurable.

This awesome finiteness of the observable universe is another fundamental truth. To symbolize it we use one of the oldest mythic images known to humankind, a serpent swallowing its tail. We call it by its Greek name, the “uroboros,” but it has also been used for thousands of years by many other cultures, often as a symbol of ultimate reality. In this ancient tradition, following Harvard physicist and Nobel Laureate Sheldon Glashow, we let an uroboros represent the range of possible sizes in the modern universe as science understands it. The size scales are arrayed along the body of the serpent, from the smallest at the tail to the largest at the head (see illustration). The Cosmic Uroboros is not the same as a circle, because even when it is swallowing its tail, it always *has* a head and a tail. There is a beginning and an end, but they are completely interdependent. The head swallowing the tail symbolizes the hope for a unified theory of all forces of nature, including gravity, which ties together phenomena on both the largest and smallest scales.

The symbol of the Cosmic Uroboros evokes the grand awareness that the universe exists on all size scales, everywhere, all the time. But although the same physical laws apply at all scales, the ones that are important on different scales are different. The Cosmic Uroboros gives us concepts for thinking truly big – and truly small. It explains conundrums, such as Scale Confusion and Scale Chauvinism, which will later help us to understand why so many problems that we have created on a global scale may be the result of inappropriately using solutions from a local or even national scale. The Cosmic Uroboros gives everything a place, and the place of humans is almost at the center, which may tell us something highly significant for understanding the possibility of consciousness—our own and others’—in the universe.

Chapter 6 Where Did We Come From? *The Cosmic Las Vegas*

What came before the Big Bang? Enveloping our slowly expanding universe there may be a superuniverse that is eternal, and in the superuniverse everything is hot, dense, random, and expanding so outrageously faster than the speed of light that no two points can ever interact. Consequently, nothing can ever happen, be created, or persist. The theory of Eternal Inflation says that every once in a while a quantum sized region – the tip of the Cosmic Uroboros’s tail – by pure chance cools enough to freeze into a bubble of spacetime in which expansion is much more sluggish. Inside that bubble time begins and things can happen and evolve. But we are now at, or perhaps beyond, the limits of science. With the theory of Eternal Inflation physics verges on metaphysics, because although the mathematics is reasonably clear, no one knows how to test it or its alternatives.

To get an idea of the Eternal Inflation theory, imagine an infinite number of gamblers flipping coins forever. If a coin comes up tails, the coin becomes half its size. If it comes up heads, it doubles in size *and* there are suddenly two of them. The odds favor growth, and once Eternal Inflation starts, it can never stop. But eternity is a long time, and some coins will come up tails again and again until they have lost so much energy that they freeze. If the theory of Eternal Inflation is right, the Big Bang was not an explosion at all but a kind of phase transition, like water that cools until it turns into ice. Like snowflakes, these coins, these tiny quantum regions, freeze into a particular

structure, and no two are alike. The brief period of freezing is the process of exiting eternity, into time. In the very first instant, like a baby sliding through the birth canal, our quantum-sized snowflake slid into time. So awesome is the energy of eternity, that the smallest possible amount of it, an amount so vanishingly small that it fell right through the floor of eternity, powers the expansion of our entire universe. As M.I.T. cosmologist Alan Guth likes to say, inflation put the bang in the Big Bang. In the 10^{-33} second during which the power of eternity overlapped with the beginning of time, our universe inflated from the size of a quantum fluctuation to the size of a human baby – from the tip of the Serpent’s tail halfway around the Cosmic Uroboros. It has taken the slow expansion of the universe 14 billion years to cover the other half of the Cosmic Uroboros and reach its present size. The face of eternity as it looked in that last instant at that tiniest of size scales is imprinted forever on our universe. The lines of that face are permanent wrinkles in spacetime. Bizarre as it sounds, space was created faintly wrinkled. These primordial wrinkles in spacetime were actually detected in 1992 by NASA’s Cosmic Background Explorer satellite, and their amplitude had been correctly predicted almost ten years earlier by Joel and his scientific collaborators. The great clusters and long strands of galaxies observed throughout our universe formed because matter in the expanding universe has for billions of years been gravitationally attracted to the wrinkles in spacetime and has been flying through space and accumulating on those wrinkles. The randomly generated wrinkles are the blueprint for the past and future evolution of the galaxies. Newsweek Magazine, quoting an interview with Joel about the discovery, called the wrinkles “the handwriting of God,” emphasizing with this graphic metaphor the startling fact that the blueprint was permanently engraved in spacetime itself before the matter that would follow the blueprint and become those galaxies was created in the Big Bang.

The theory of eternal inflation predicts infinite universes, each with its own Big Bang and possibly different laws of physics. Einstein said the only question that really interested him was, “Did God have a choice?” If other universes follow different laws of physics, then God may not only have had choices but is trying them all out.

The theory of “cosmic inflation” describes that last fraction of a second before the Big Bang during which the random wrinkles were generated. People wondered, what could have caused cosmic inflation? Extrapolating the equations backwards, it appears nothing caused it. Perhaps the question should really be, what stopped inflation? Inflation, according to the theory of eternal inflation, is the natural state of reality outside our universe. It is what eternity does. Although the theory of eternal inflation is highly speculative, cosmic inflation has actually passed several crucial scientific tests.

The Cosmic Las Vegas metaphor helps illustrate the random, quantum nature of eternal inflation, but gives no sense of what eternal inflation may mean if it is true. We have crashed against the limits of ordinary language, and any earthbound metaphor will be misleading. So we will borrow an image from an ancient religious tradition with a similar story: the medieval Jewish mystical tradition of Kabbalah. Kabbalah held that the universe (they meant the medieval universe of the spheres) began in a point containing the blueprint for the world, and the point expanded. Kabbalah can be a useful aid in visualizing the transition from mystery to the physical universe. According to Kabbalistic cosmology, in the beginning God was everywhere. There was no space for a world. In order to make space (as we have pointed out in Chapter 2) God withdrew into

Himself from a certain point that contained all wisdom. As God withdrew, the point expanded into the void God was creating within Himself, and this expansion was the world. God, however, was now in exile from the world, and thus evil was possible in it. The Kabbalists developed and named concepts to correspond to each feature of this creation process, including the other-worldly reality that preceded and was thought to still surround the creation. We two were struck by how well those concepts, although developed in a radically different mindset, can describe the theory of eternal inflation. We have re-interpreted the Kabbalistic Tree of Life, a symbol used to describe the stages of creation, to apply to eternal inflation, our best scientific theory of creation. We were struck not only by the physical imagery of the Kabbalistic creation myth but also by its social and political history, which illustrates how a cosmology in some ways similar to our own became a model for human meaning and allowed a people to find in their experience of exile and persecution a cosmic purpose.

Chapter 7 Are We Alone? *The Possibility of Alien Wisdom*

The existence of aliens is not a matter of faith or belief. It is a scientific question, and we are now trying to answer it by searching the universe for planets, signs, and signals.

If there is other intelligent life in the universe, we know some things about it. Science rules out certain possibilities, such as truly tiny or gigantic intelligent organisms. Intelligent aliens are likely to be about the same size as we are, although communities or integrated networks of smaller or larger creatures are also possible. Furthermore, all the ways we have discussed in which humans are central to the universe are likely to be shared with other intelligent beings

SETI – the search for extraterrestrial intelligence – is only 50 years old. We are still developing new ways to discover other technological intelligences. For us to be able to detect them, they need to emit some sort of radiation, or at least to modify their environment in ways that can be perceived remotely. Early searches looked for radio waves from some of the nearest stars at particular frequencies that seemed plausible choices for communication. More recent SETI efforts have scanned a much broader range of radio frequencies from more distant – but still relatively nearby – stars. Since humans have started to use laser light to transmit information, SETI has also started to look for laser signals from space. So far, no intelligent signals have been detected. But lack of evidence is not evidence of lack, and any day the search could pay off.

Meanwhile, astronomers have begun to discover planets around other stars. We now know of many more planets outside the solar system than the nine planets in it. As more discoveries are made, we are starting to find planetary systems with multiple planets. But almost none of these systems look anything like our own solar system. The most common finding is a massive planet like Jupiter orbiting close to its star. However, astronomical theorists agree that Jupiter-like gas giant planets could not form so close to their star. They predicted that some of these planets could have formed far away and then moved closer, but any small earth-like planets would almost certainly have been destroyed in the process. So earth-like planets might be rare.

Earth is especially hospitable for life in many ways. Its rotation is stabilized by its unusually large moon, which was probably formed as a result of a chance impact of a

large proto-planet with the early earth. Although this cataclysm would have destroyed any early oceans, subsequent smaller comet impacts brought the earth its water and many of the other chemical building blocks of life. Since then, the earth has been protected from frequent comet impacts by the gravity of Jupiter and the other giant outer planets of the solar system. However, occasional major impacts have occurred, such as the one that killed the dinosaurs and many other species about 65 million years ago.

The earth's orbit around the sun lies in the "habitable zone" – far enough from the sun for water to be liquid, but not so far that water would be permanently frozen. Moreover, the earth has been in the habitable zone for its entire lifetime. Stars like the sun grow hotter as they age because the nuclear furnace at the stellar core becomes polluted with helium, the ash of the fusion process that powers the sun. At the beginning of the solar system, when the sun was emitting about 30% less heat than it now does, the earth was at the outside edge of the habitable zone. Now it is near the inside edge. Since the evolution of intelligent life – us – required the entire 4.6 billion year history of the earth, a planet that was not so fortunately located might not have had sufficient time.

Although we now understand the main outlines of the evolution of life on earth, we are only beginning to discern how life may have started. Primitive life may be common in the universe, since the earliest living organisms on earth appear to date from only about 100 million years after the last major impacts. All life on earth shares the same genetic code, so it all evidently descended from the same early organism. The most primitive forms of life yet discovered are living in the hydrothermal vents on the sea floor, so it is possible that similar life could have originated even in the oceans beneath the ice that covers Jupiter's moon Europa. However, it took two billion years before cells on earth developed nuclei and another billion before multicellular creatures appeared and invented sex. Complex life forms began to appear on earth only a little over half a billion years ago. Maybe evolution reaches beyond primitive life only in the most unusual circumstances.

Once a technological species embarks on space flight in a determined way, only a few million years would be required to explore and perhaps colonize an entire galaxy. The great physicist Enrico Fermi therefore argued that if alien intelligences exist, we should know about them, but "Where are they?"

It is possible that the conditions that led to the appearance of intelligent life on earth are so rare that we are the only intelligent creatures on all the planets around the hundred billion stars in the Milky Way galaxy – perhaps even in the entire visible universe. If we are alone, then we are the first creatures who have begun to understand the cosmos, and we are significant in an almost terrifying way.

St. Augustine enunciated the Christian doctrine, "the deliberate sin of the first man is the cause of *original sin*." To fail to take adequate care of the earth and thereby destroy the only intelligence in the universe would surely be a *final sin*. How insane and cosmically tragic to wipe ourselves out over trivia!

On the other hand, it is also possible that we or our descendants will some day come into contact with aliens whose long-lived civilization possesses far more than amazing scientific knowledge. They could also possess alien wisdom about how to thrive as a planet, in a culture that has succeeded in nurturing its members for millions of years without depending on material growth.

Part III THINKING COSMICALLY, ACTING GLOBALLY

Chapter 8 Developing a Cosmic Perspective on Earth's Problems

Our universe is the ultimate model for our reality.

It is unusual to look at something larger and more foreign to understand something smaller and more familiar, but that is exactly what we are proposing. This is a return to the ancient maxim, “As Above, So Below,” but we no longer mean it literally as a statement about geography. Away from earth there is no above or below – but metaphorically on the Cosmic Uroboros, and within each person's sense of self, there is.

Modern culture has totally confused being scientific with taking things literally. This is unfortunate, because they are in practice almost opposites. Those people who believe that any text written in human-coined words can be taken absolutely literally are the least open to imagination, to scientific discovery, or to surprising evidence of any kind. Science is both a consumer and creator of metaphor and is meaningless without it!

If we choose our images carefully to reflect as accurately as possible the ground rules of the universe as science is discovering them, we can translate those discoveries into a meaningful and positive overview of our global situation. This chapter presents three examples of how cosmological principles applied metaphorically to political problems give us a clearer understanding of the scale and legacy of today's decisions

*** Collectives of Humans are Not People: Political lessons from the Cosmic Uroboros**

The Cosmic Uroboros gives us a way of talking about the universe, appreciating it, and understanding our seamless continuity with it – but also the expectation that there will normally be profound discontinuities every few powers of ten in size. If discontinuities are created by increasing complexity, then they will occur not only in physics but in politics as decisions must be made concerning vastly larger numbers of people with complicated differences among them.

Samuel Huntington, Professor of Government at Harvard, describes himself as a liberal domestically but a conservative in foreign and military policy, because liberals can't run wars. Liberals assume everyone must be treated equally, and all have rights. But the military must see everyone as a potential enemy, and be prepared to beat them. Liberals, according to Huntington, don't realize that “liberalism can only work where security is taken for granted” and the military never takes it for granted.

Huntington's position makes better sense if seen in a cosmic context. Many people, both liberal and conservative, believe that it is hypocritical, dishonest, or in some other way morally defective to hold “inconsistent” views abroad and at home. But the Cosmic Uroboros suggests that what may at first appear to be inconsistency is rather an example of the relevant principles changing at different size scales.

Liberalism can and does work in a society of law, like the United States, where we have institutions that represent our principles. But no corresponding system of law governs the relationships of countries to each other. There are natural affinities among similar nations, but on the global scale it's a jumble out there. There is no international

government, just the slow pacing of large cats eyeing each other warily. On that scale, far outside the special brotherhood of civil society, it is possible that some ideas of liberalism lose their relevance, and success may be controlled by other laws – laws of skepticism, self-defense, and mutual accommodation. People are much kinder, wiser, and more generous as individuals than on the collective level, as Lewis Thomas pointed out in his brilliant essay on the Iks, an unfortunate African tribe. It seems that people on the collective level, namely as committees, cities, or countries, are almost never kind, wise, or generous. A collective of human beings is a special creature and does not follow the same laws of behavior as an individual. The military must see the enemy as a collective and therefore worse than almost any individual. A collective needs to be approached so differently from an individual that this also calls into question whether it is wise to give corporations all the rights of individuals. The Cosmic Uroboros makes sense of why there is not necessarily something dishonest or hypocritical in treating people differently on the collective vs. individual scale.

*** Inflation Must Stop in This Universe: Ecological Lessons from the Big Bang**

Inflation is the controlling metaphor of our culture today. Not only is the human population inflating; so too are the average technological power and the resource use of *each* individual. The human race is addicted to exponential growth. Our problems on earth are careening onto new size scales at inflating rates, and most people have trouble mentally grasping the reality of what is happening. We are like deer blinded by headlights, paralyzed by the sight of what is too rapidly approaching. We lack language, concepts, and an overarching vision that can explain what is happening on all relevant scales, what it means, and what we need in order to survive in harmony with the universe. Applying Cosmic Inflation as a model for earth, we realize that in the finite environment of our planet, human inflationary growth must end, however cleverly we may postpone or disguise the inevitable. *How* it ends will determine the character of our collective future.

Inflation is like musical chairs. When the music stops, the accidental arrangement of where people are standing at that moment determines who gets the chairs, and similarly, the conservatism or liberality of the time, the fears and myths of the moment and the powers that be when current inflationary growth stops, may become enshrined for the very long term. Unlike musical chairs, the inflationary music won't start again. Our grandchildren will have to live with the results. When science reveals a natural limit, humility before the truth is the essence of wisdom for our time. You can't time travel into the past to undo it. You can't move faster than the speed of light. The last moments of inflationary growth set the pattern for the long-term. If we accept such limits, we can direct our efforts toward changing the things we can. There may be powerful people who find these ideas subversive. An idea once unleashed can never be pulled back, but people who hold it can be killed or silenced by those who feel threatened by it, as happened to Giordano Bruno and Galileo. Nevertheless, political and social decisions of our special time carry a weight far beyond the obvious. We may wish or pretend this is not so, but Mother Nature gets the last word.

The single most important question for the generations of humans alive today may be this: how can global civilization make the transition gracefully and justly but quickly from inflating consumption and inflating expectations to a sustainable level?

The Big Bang was the cosmic transition from infinitely accelerating inflation to slow and steady expansion. If earth works the same, then *inflationary* growth must stop, but that does not mean that *all* growth must stop, even though some people in good faith assume so. Processing information, which occupies more and more of the world's population, does not need to be environmentally costly. Human life can continue to be enhanced as long as our creativity in restoring the earth stays ahead of our material growth. As the universe demonstrates, inflation transformed to expansion can go on for billions of years.

*** Gravity is the Ultimate Capitalist Principle: Economic Lessons from Black Holes**
Gravity is the ultimate capitalist principle because it inexorably makes the rich richer and poor poorer. If a region of the universe is denser than average (called in astronomy a “rich” region), it expands more slowly and attracts more matter, while one that is less dense than average (a “poor” region) will tend to empty out compared to rich regions. Gravity alone would collapse the matter in every galaxy into a black hole. Fortunately, nature has counterbalanced gravity with circular and random motions. Stars revolve around the center of spiral galaxies and they move more randomly in elliptical galaxies, and planets orbit around their stars. These motions maintain dynamic stability and hold the one-way plunge of gravity at bay. As a result galaxies can provide a long-lived environment for the formation of heavy elements and planetary systems with earth-like planets, life, and ultimately us.

Wealth tends to concentrate the way matter does under gravity, and the widening gulf between rich and poor in the United States and in the world needs to be counterbalanced by other forces of regulation, redistribution, and large-scale justice. Otherwise the global economy could plunge into an economic black hole – and a black hole is irreversible. Once an object collapses into a black hole it is forever lost from the universe. People in a democracy tend to believe that all political mistakes can eventually be undone, and as a result they allow things they do not want in order to avoid a fight in the short term. Using gravity as a possible model makes clear the potentially catastrophic error of assuming that all collapses can be reversed. Understanding gravity as a metaphor is a warning that we need to work more quickly to get to where we want to be before the inflationary music stops.

Chapter 9 – New Views of the Universe, New Views of Ourselves

Expanding perspective is the great gift of modern cosmology to present day culture. The universe is a boundless source of inspiration, but it transcends all verbalizable concepts. We can't escape dependence on earth-linked metaphors for describing the universe, including those aspects beyond human experience and imagination. Nevertheless, this is not as bad a limitation as one might think. The astonishing richness of human life has given us countless metaphors and metaphor systems, including the most powerful kind – religions. That we have any tools at all with which to describe the universe as a whole is a stupendous gift of evolution. It did not have to be so, and in fact never has been, as far as we can tell, for any other species. Metaphor is the key to enlarging not only our perspective but our consciousness.

Metaphor is a kind of relationship between ideas, but no one can tell you what kind of relationship, exactly. If we did not speak in this imprecise, suggestive, impulsive, gut-led way, we would never be able to say anything until we understood it perfectly. The human world would be a quiet place. Words suggest, we banter them around, and the meanings gradually get polished and accepted. Metaphorical understanding is limitless but by definition incomplete. People often have the impression that science is outside this process – that because it uses mathematics to describe quantitative relationships, it is therefore objective, logical, and precise. But scientists don't talk to each other in mathematics but in words like everyone else. In the tossing back and forth of ideas, embodied in words, the meaning of mathematical expressions is found or created. Many if not most scientific terms are metaphors, e.g. energy, force, inflation, field, particle, wave, momentum, and law. A medieval Englishman would have said that heavy things fall because they are “kindly enclyning” toward the earth, while a modern physicist would invoke the law of gravity. As C. S. Lewis pointed out, both the medieval reference to personal inclination and the modern reference to legislation are metaphorical. Words like “law” or “force” have become so commonly used in science that many scientists feel viscerally that the scientific definition is correct and other usages are sloppy – even though those usages predate the scientific one. By now we cannot even think of the word “energy” without being aware of the existence of a precisely defined and measurable quantity. Science has borrowed these terms, changed them, and returned them to the world with a new level of meaning associated with them. This is the standard pattern.

The metaphorical nature of science is not a dirty little secret but an opportunity for creativity in science and for enriching the thought processes of the general culture. A determined drudge of an author may be able to drain his text of all his own emotion, but he cannot drain it of the emotions of the countless millions who have created the words he uses. Even the driest textbook, with argument building upon argument, lays out a logical structure built ultimately of poetic impressions.

Throughout human history, and doubtless also pre-history, the way people visualized their internal world – the world of spiritual experience – was with images borrowed from the outer world. There was a sacred mountain, a tree of life, a god of sweet water. All metaphors were naturally taken from the outer world. What else was there? But today, the imagery of most people's internal world is left over from earlier universes – the flat earth of the Bible, or the heavenly spheres of medieval Europe. We know perfectly well we don't live in those universes. There is real dissonance between the colorful, volatile world we actually live in and the monotonously recycled language religions use to describe “ultimate reality.” Anything described in tired metaphors from an admittedly unreal world must inevitably be accompanied by doubts and eventually boredom and indifference. Indifference to the universe itself is a staggering reality of our time.

Where are better ideas supposed to come from? Science. Science has a reputation as cold, precise, unfeeling, and respectable. But science is not just hypodermics and higher mathematics. The story it's telling about the universe reveals the primal source of our passions and hopes. Now all we have to do is open our emotions to the possibility that this story is true.

* **Big Evolution – What We Truly Could Be**

There is tremendous power in realizing that “I am what the expanding universe is doing here and now!” To find this power and to let inspiring but scientifically accurate concepts guide our thinking are the goals of a psychologically and socially functional cosmology.

Seventeenth century science underlies the existential philosophy that says individuals are insignificant, isolated in a universe indifferent if not hostile to us. This philosophical view has led to the sad result that the phrase “I’m human” usually means “I make mistakes” or “I have my limits.” It is a self-fulfilling prophecy to think of “human” as being a limiting identity. But the new cosmology reveals the obsolescence of this view. As we have seen, human beings are significant and central to the universe in at least six ways that follow directly from astronomy and physics. 1) We are made of the rarest stuff in the universe. 2) We are at the center of all possible sizes, and life of our complexity could only occur there. 3) Because of the finite speed of light, we conscious beings are always at the center of Cosmic Spheres of Time. 4) Because the expansion of the universe has begun to accelerate, we find ourselves living on the midpoint of time. 5) We are also at the midpoint of the life of our sun, late enough to have evolved, early enough to have a multi-billion year future. 6) If eternal inflation is right, our universe is one of the vanishingly rare spots in the eternal superuniverse where time exists and history can unfold.

A truer meaning of “I’m human” is, “I stand here on the Cosmic Uroboros, midway between the largest and the smallest things in the universe. I can trace my lineage back 14 billion years through generations of stars. I am made of elements that were created in stars and could not become part of any planet until those stars had exploded as supernovae and sent their contents flying through spacetime to become part of a newly forming second generation solar system. And back beyond those creator stars to the time when the particles in my body today were mixed in an amorphous cloud of dark matter and atoms in the forming galaxy, expanding with the early universe. Billions of years of experiments have produced me. I am connected mathematically, physically, cosmically, and consciously with all the scales along the Cosmic Uroboros.” If we recognize our importance in the universe, we are more likely to discover the will to change the world as necessary to insure our survival.

Until recently no one ever dreamed reality was anything but Midgard – that is, the universe as seen on the size scales of human experience, the part at the bottom of the Cosmic Uroboros. For a person who conceives of the universe as Midgard, “infinity” means an endless amount of Midgard. Naturally, therefore, to such a person a “transcendent” realm would be something imagined as *outside or beyond* the universe. But now we know that in this universe the rules must change with exponential increases in size scale. For the first time science is actually observing what lies beyond Midgard and realizing how provincial we have been. Transcendence is not beyond the universe, as if that even meant anything. *Transcendence is what happens many times within this universe, every few powers of ten.*

For example, on the atomic and subatomic scales, “human” means nothing. There is no humanness to our atoms. Whether atoms are inside us, inside a rock, or drifting through space, is all the same to them. To our conscious understanding, atomic behavior is fundamental to what we are, but on the atomic scale, even inside our own bodies, we

do not exist. Humanity transcends the world of atomic interactions. And from the perspective of any size scale substantially larger than Midgard, *we* must be utterly different from what we have always assumed.

For each of us, “what we truly are” is not fixed or objective. Our identity runs only as deep as our knowledge of where we came from. Every human has a right to claim ancestry back at least to the Big Bang. Indigenous people tend to respect their ancestors, especially the earliest, mythic ones – the founders, the heroes of the tribe’s story of creation. Keeping open a mental window to their deepest origins expands those people’s consciousness beyond the everyday, and thus their identity follows suit. We examine one shamanic cosmology to see if we can learn from their worldview how to open ourselves to the meaning of our own emerging scientific cosmology – how to respect our ancestry, human and otherwise, and how to experience it in ourselves through imagery that speaks to our time. Like earlier peoples, we grow when we expand our identity to encompass our earliest ancestors – those great swirls of matter and energy, shepherded by the same force holding you in your chair at this very moment, that acted out the drama of creation fourteen billion years ago and are still at work in your body, thinking your thoughts and turning your food into your life. This is a deeper meaning of the Biblical commandment, “honor thy father and thy mother.” As our sense of identity expands to embrace what science is discovering about cosmic history, we become capable of experiencing ourselves as the human dimension of this universe and powerful enough to effect change.

* **Harmony with the Cosmos as a Global Goal**

We need to see our planet and our own behavior from a new perspective – and that is what cosmology is providing. Scientific cosmology does not in any way concern itself with human morality, but if there is to be a morality for our time, it must be *consistent* with the new cosmology. That is the premise of this part of the book. What short-term politics often justifies today as moral behavior is inconsistent with what cosmology is telling us about long-term survival.

To maintain human behavior in harmony with the universe was the goal of many ancient cultures but seems radical if not absurd in our cynical world. Religions have lost their power with arrogance and tired metaphors, and science avoids moral discourse, so no one talks about harmony with the real universe. Music doesn't become boring because it is in harmony. Harmony is what keeps it beautiful. Harmony ought to be the bottom line of our lives, but in fact although living in harmony with the earth is finally starting to mean something for many people, few ever think about living in harmony with the universe. It is not even possible to live in harmony with a universe one doesn't know about and can't begin to imagine.

At this pivotal moment in human history disharmony among ourselves could lead to our extinction, along with most of the higher forms of life. For lack of a coherent picture of reality, “As Above, So Below,” has been turned upside-down to “As Below, So Above.” Chaos below has left an image of chaos as cosmic reality. It is no wonder that cynicism reigns. Harmony with the universe we know, is the essence of a cosmology that works for human beings. The modern world needs a cosmology that will help us grow into the beings we need to become to survive in the long term.

Ultimately there is no functional cosmology without art, because the meaning of a cosmology flows from the language and imagery chosen to express it. In the mental confines of any traditional picture, the greatest teachers, the most creative artists, and the noblest intentions in the world, together, cannot make sense of the universe for the 21st century. But if they build on the discoveries of modern scientific cosmology, they could do what scientists alone cannot do: create a visual and poetic language through which the universe as we now understand it can speak to our global, science-based culture. The greatest gift of cosmology to our time will not be new technologies or cures for disease but life-changing metaphors to expand our sense of what is real, what is possible, and who we ourselves could be. Cosmology may not have any immediately practical use except to help create a longer and more majestic perspective on our blue earth and its problems. But the possibility of true majesty in a cynical world may end up being the most valuable thing any science can give us.