COSMOLOGY AND SCIENCE

'Who has not felt a sense of awe when looking deep into the skies lit with countless stars on a clear night? Who has failed to wonder whether there is an intelligence behind the cosmos? Who has not questioned if ours is the only planet to support living creatures?'

Dalai Lama

The Scientific View of the Universe

Throughout human history, human beings have marvelled at the grandeur and mystery of the cosmos and wondered what place they have in it. In the words of scientist and philosopher Ravi Ravindra: "Something in us can only be satisfied by returning to some form of inquiry about our own nature and our relationship with others and the cosmos. Who am I? Why am I here?"

> Every human being sometimes wonders about the universe in which we live, about its vastness, about the variety of manifestations in it, about the endless transformations of substances and energies, and the intricate laws by which all this is regulated. That the universe exists is a wonder! And that it works and continues to exist is even a greater wonder. Each one of us is thus some sort of a scientist. We may not undertake investigations of the cosmos and the forces and laws governing it rigorously or in any systematic manner. But we can hardly be uninterested in the place where we have our being, where the Spirit manifests itself, where all the aesthetic possibilities are realized, and where precise intellectual formulations find their concrete expression. Moreover, not to wonder about one's own existence – its meaning, function and purpose – is that possible? One could hardly be oblivious either to the mystery of one's own existence, or to the mystery of the cosmos. Both mysteries exist, perhaps parts of one larger mystery. In the vastness of the universe, I am a small particle! But, equally true, I am the center of my cosmos. What is myself? (1)

The scientific study of the physical universe has revealed a cosmos of vast dimensions of space and time, and inherent complexity of both matter and energy. "What the modern sciences have brought, in terms of the understanding of physical mechanisms, is a great treasure. One is rightfully awed by the astronomical views made possible by the Hubble space telescope and by the pattern of DNA that forms the genetic underpinning of all life. To ponder the mathematical unraveling of our Cosmos' material unfolding, or to trace the gradual development of man's three brains in evolutionary biology – each of these are pursuits to be greatly valued."

> The scale of the universe is awesome. Our sun, which is more than a million times greater in volume than the earth, is only a tiny speck in the unimaginable vastness of the Milky Way. Hundreds of billions of such suns make up this galaxy, most of them far greater in size than our own. And the galaxy itself is but a tiny speck among countless billions of galaxies that occupy the cosmos that science perceives. Each sun is an ocean of energy, one tiny fraction of which is enough to animate the life of our earth and everything that exists upon it. Every second there pours forth from the Sun an amount of energy equal to four million tons of what we call matter. Since the planets of suns capture so little of this energy, all of outer space is in reality a plenum of force that is largely invisible to us, yet life-giving. To set our minds reeling, it is enough to contemplate the bare distances that astronomy has measured. Light traveling at 186,000 miles a second takes 800,000 years from the galaxy Andromeda to reach us. Yet this galaxy is now considered a member of what is called the local cluster of galaxies, beyond which lie countless stars and groupings of stars thousands of times more distant from us than Andromeda. As with size, energy and distance, so with the reaches of time. Astronomers say the earth is some five billion years old, which means that the entire history of mankind, as we record it, is but a fraction of a second in the time scale of the earth. It is no exaggeration to say that in this picture of the universe man is crushed. Within cosmic time he is less than the blinking of an eye. In size he is not even a speck. And his continued existence is solely at the mercy of such colossal dimensions of force that the most minor momentary change in these forces would be enough to obliterate instantly the very memory of human life. (2)

Most astronomers believe that the physical universe emerged from an infinitesimal point of incredibly concentrated energy in the form of a “Big Bang” some 13.7 billion years ago. As the universe began to expand in the first few seconds, the intensely hot temperature diminished rapidly, allowing reactions to occur which created the nuclei of the lighter elements such as hydrogen and helium, from which subsequently all the matter in the universe came into existence.

It was only after elementary particles of matter began to form that the four primary forces of nature – gravity, electromagnetism, and the strong and weak nuclear forces – appeared and began functioning. Gravity is the force of attraction between bodies; electromagnetism is the force between electrically charged particles; the strong nuclear force binds the particles in atomic nuclei together; and the weak force is responsible for the phenomenon of radioactive decay.

Dr. Keith Buzzell describes the point at which the universe emerged as “a transition from a state of absolute *nothingness* to a state of nearly infinite energy, which bursts forth in the creative impulse of the Initial Moment. Laws, as modern physics defines them, appear to emerge at precisely the Initial Moment, with no indication that the laws could exist prior to that time.”

The creation of elementary subatomic particles and the four primary forces set the stage for subsequent developments:

> The simple elements were formed out of this soup of hot primordial particles. Hydrogen and helium atoms were formed. These produced huge clouds, or nebulae, which started breaking up into smaller units. These, in turn, started condensing due to their own gravitational pull, thus forming the basis for the evolving galaxies. The clouds of matter within these nebulae became more and more compact, which caused a rise in temperature of their centers. The first protostars appeared in the form of blobs of glowing hydrogen gas. In time, very high temperatures were reached inside their cores. These temperatures kept rising until nuclear reactions were eventually achieved. The nuclear reactions produced much heat and light; thus, the first heavenly bodies, similar to our sun, were born. In the core of these stars, heavier elements were being cooked, and eventually a variety of elements that make up our present physical bodies were synthesized in the stars. (3)

The accidental discovery by astronomers in the 1960s of background microwave radiation throughout the universe was widely interpreted as evidence of an "echo or afterglow of the events of the Big Bang" and seemed to confirm the validity of the emerging theoretical models of the origins of the universe. Physicist Stephen Hawking: "Fluctuations in the cosmic microwave background radiation are the fingerprints of creation, tiny irregularities in the otherwise smooth and uniform early universe that later grew into galaxies, stars, and all the structures we see around us."

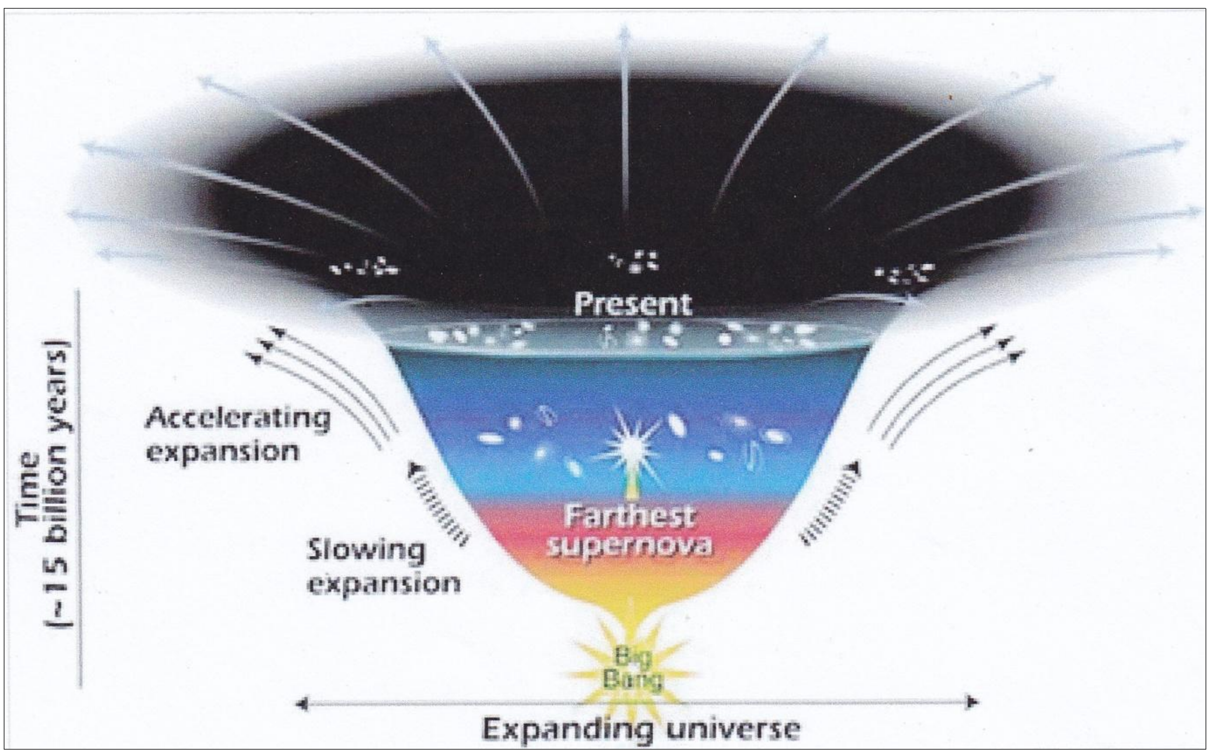
Despite the apparent sophistication of current theories of the creation of the universe, scientists are unable to answer certain fundamental questions: What existed before the Big Bang? Where did the Big Bang come from and what caused it? Dr. Jon Kabat-Zinn reflects on these compelling questions: "We are still faced with something coming out of nothing, space coming out of 'before space' and time beginning at a certain point, before which there was none, and all matter coming out of nowhere as infinite pure energy." For almost a century physicists have pondered this quandary: If space-time did not exist before the Big Bang, how could something appear from nothing? A number of physicists, including Stephen Hawking, have proposed that our universe spontaneously came into being through a "quantum fluctuation in a pre-existent vacuum." However, this hypothesis does not truly resolve the great paradox of a 'birth out of nothingness' and seems to produce more questions than answers.

Our ability to understand the earliest stages of the expansion of the universe through observations made by powerful telescopes is limited by the speed of light. Physicist Alan Lightman: "No matter how big our telescopes, we cannot see beyond the distance light has traveled since the Big Bang beginning of the universe. There simply hasn't been enough time since the birth of the universe for light to get from there to here. The maximum distance we can see is only the *observable* universe. But the universe could extend far beyond that."

> With our largest telescopes, we can see very deep into space, but we must bear in mind that in doing so we are simultaneously seeing back in time. The light that reaches our eyes has traveled for a long time – up to several billion years. We can only infer the current state of affairs in the distant reaches of the universe because our direct astronomical observations are always of events long past. However, from a careful analysis of these observations, we can construct a likely story of how our galaxy and, indeed, the whole universe formed and what it is like even in those sectors currently unseen by us. (4)

For most of the 20th century astronomers believed that the expansion of the universe would eventually slow due to the influence of gravity. But near the end of the century, observations of very distant supernovae from the highly sensitive Hubble telescope indicated that, in fact, the expansion of the universe has been *accelerating* for the last 7.5 billion years.

Figure 1. Expansion of the Universe since the Big Bang



Many scientists now theorize that the faster rate of expansion may be due to an unperceived 'dark energy' that is pushing galaxies apart. It is believed that 68% of the universe is 'dark energy,' 27% is 'dark matter' and only 5% is visible matter and detectable energy. This mysterious 'dark energy' has sometimes been described as a dynamic vibratory field of energy similar to the ancient Greek fifth element *aether* or 'quintessence,' or the *akasha* of Hindu philosophy. Physicist David Bohm argues that the presence of 'dark energy' and 'dark matter' in the universe challenges certain premises of the concept of the Big Bang theory of creation:

> Reality contains immensely more than science may happen to know, at this moment, about the universe. For example, the universe may involve laws that go far beyond those on which the current theory of the big bang is based. Therefore it is quite possible that the big bang is only incidental in a totality that is immeasurably more than anyone could ever hope to grasp as a whole. Current quantum field theory implies that what appears to be empty space contains an immense "zero point energy," coming from all the quantum fields that are contained in this space. Matter is then a relatively small wave or disturbance on top of this "ocean" of energy. Using reasonable assumptions, the energy of one cubic centimeter of space is far greater than would be available from the nuclear disintegration of all the matter in the whole universe! Matter is therefore a "small ripple" on this ocean of energy. But since we, too, are constituted of this matter, we no more see the "ocean" than probably does a fish swimming in the ocean see the water. What appears from our point of view to be a big bang is thus, from the perspective of the ocean, just a rather small ripple. (5)

Limitations of the Scientific Approach

The scientific discoveries about the nature of the universe are based on two general methods: induction and deduction. In the process of induction phenomena are studied in order to infer underlying laws and principles. With deduction, the perception or discovery of general principles leads to the application of these laws in specific circumstances. For instance, the theory of relativity emerged from "thought experiments" conducted by Einstein (principles) which were later confirmed by actual experiments and celestial observations (facts). The philosopher F.S.C. Northrop described the mutual relationship between the two approaches: "Any empirical science in its normal healthy development begins with a more purely inductive emphasis and then comes to maturity with deductively formulated theory in which formal logic and mathematics play a most significant part."

Classical physics was built on the foundation of the Cartesian method of analyzing the world into discrete parts and structuring those parts according to causal laws. The resulting deterministic picture of the universe was similar to the image of nature as a clockwork mechanism. Stanislav Grof: "The various scientific disciplines based on the mechanistic model have created an image of the universe as an infinitely complex assembly of passive, inert and unconscious matter, developing without any participation of creative intelligence. From the Big Bang through the initial expansion of the galaxies to the creation of the solar system and Earth, the cosmic processes were allegedly governed by blind mechanical forces."

> The principal feature of this order is that the world is regarded as constituted of entities which are *outside of each other*, in the sense that they exist independently in different regions of space (and time) and interact through forces that do not bring about any changes in their essential natures. The machine gives

> a typical illustration of such a system of order. Each part is formed (e.g. by stamping or casting) independently of the others, and interacts with the other parts only through some kind of external contact. By contrast, in a living organism, for example, each part grows in the context of the whole, so that it does not exist independently, nor can it be said that it merely 'interacts' with the others, without itself being essentially affected in this relationship. Physics has become almost totally committed to the notion that the order of the universe is basically mechanistic. The most common form of this notion is that the world is assumed to be constituted of a set of separately existent, indivisible and unchangeable 'elementary particles,' which are the fundamental 'building blocks' of the entire universe. (6)

The prevailing world view of modern science is essentially *materialistic* and *reductionistic*, producing a subject-object split which emphasizes the study of the object (phenomenon) while disregarding or downplaying the subject (mind, consciousness). Professor Jacob Needleman explores this ontological position:

> Science since Galileo can be understood as a mode of approaching the world in which one aspect of the phenomenal world is given the privileged position of primitive, irreducible fact: the aspect of pure corporeality. The notion of pure corporeality as the reality to which science attends and to which all phenomena are to be reduced is the concomitant of a dictate to the perceiver that he remove himself from the world in order to gain knowledge of what he perceives. The roots of this dictate can be seen most strikingly in the thought of Descartes, whose isolation of the realm of consciousness from that of the body and the perceived world leads to this remarkable notion of a pure corporeality which, while devoid of consciousness, is accessible to mathematical knowledge. If we wish to speak of a basic substance to which all phenomena coming within the sphere of scientific explanation are reduced, it would be this pure corporeality. At the same time, it is important to keep in mind that this concept of pure corporeality is the product of a frame of mind, or attitude, or methodological dictate: namely, to keep the self out of its world as it investigates its world. (7)

The language of science (and everyday life) tends to divide things into seemingly separate entities which appear fixed and static in their nature. In this way the unity and wholeness of reality is divided into differences and distinctions, leading to the illusion that the world is actually constituted of distinct, independent fragments. David Bohm: "In scientific research fragmentation is continually being brought about by the almost universal habit of taking the content of our thoughts for 'a description of the world as it is.' In this habit, our thought is regarded as in direct correspondence with objective reality."

Bohm proposes that scientific theories should be provisional and flexible, able to adapt to new 'facts' which emerge from experimental and other studies. "Our theories are not ‘descriptions of reality as it is’ but, rather, ever-changing forms of insight, which can point to or indicate a reality that is implicit and not describable in its totality.”

> Instead of supposing that older theories are falsified at a certain point in time, we merely say that man is continually developing new forms of insight, which are clear up to a point and then tend to become unclear. In this activity, there is evidently no reason to suppose that there is or will be a final form of insight (corresponding to absolute truth) or even a steady series of approximations to this. Rather, one may expect the unending development of new forms of insight (which will, however, assimilate certain key features of the older forms as simplifications, in the way that relativity theory does with Newtonian theory). However, this means that our theories are to be regarded primarily as ways of looking at the world as a whole (i.e. world views) rather than as ‘absolutely true knowledge of how things are.’ (8)

Universal human experience and the philosophical study of the underlying assumptions and worldview of science itself affirm that there are significant aspects of reality which can only be partially understood by the perspectives and methods of scientific investigation:

> Science can never tell us why a sunset or a string quartet is beautiful. This is no argument against science, merely an acknowledgment of its limits. It can analyze the sunset into wavelengths of light and the effect of refraction on them as they pass through the earth’s atmosphere, just as it can analyze Beethoven’s music into vibrations in the air, which is what music is. But it will never arrive at how these purely physical phenomena can produce in a sensitive consciousness a mystical feeling of beauty and awe. (Indeed, in neuroscience, this is known as the problem of *qualia*, how ‘qualitative’ phenomena – colour, sound, beauty, awe – can arise from quantitative ones – neurons or molecules.) (9)

The scientific understanding of nature is based on measurement and quantity, and disregards the more subtle, metaphysical dimensions of quality, value, purpose and meaning. Physicist Max Planck once famously said: “That which cannot be measured is not real.”

> The scientific method itself has fundamental limits, and many important areas lie outside those limits. Science can’t deal with values, ethics, aesthetics, or metaphysics, and these limits of science follow from the very nature of the scientific enterprise and its methods. When science studies the nature of cosmology, for example, it does so on the basis of the specific laws of physics that apply in the unique Universe we inhabit. It can interrogate the nature of those laws, but not the reason for their existence, nor why they take the particular form they do. Neither can science examine the reason for the existence of the Universe. These are metaphysical issues, whose examination lies beyond the competence of science per se . . . Neither can science investigate the issue of whether or not there is an underlying purpose or meaning to physical existence,

> for these are non-scientific categories. However these issues are of significance to us; in particular they underlie the existence of humanity. (10)

The pre-scientific view of the cosmos of traditional cultures included intelligence, purpose and meaning as integral components of the universe. Jacob Needleman: "There is a great difference between contemplating a universe which exceeds me in size alone or in intricacy alone, and one which exceeds me in depth of purpose and intelligence. A universe of merely unimaginable size excludes man and crushes him. But a universe that is a manifestation of great consciousness and order *places* man, and therefore calls to him."

> Ancient man's scale of the universe is awesome, too, but in an entirely different way, and with entirely different consequences for the mind that contemplates it. Here man stands before a universe which exceeds him in quality as well as quantity. The spheres which encompass the earth in the cosmological schemes of antiquity and the Middle Ages represent levels of conscious energy and purpose which "surround" the earth much as the physiological function of an organ such as the heart "surrounds" or permeates each of the separate tissues which comprise it, or as the captain's destination "encompasses" or "pervades" the life and activity of every crewman on his ship. In this understanding, the earth is inextricably enmeshed in a network of purposes, a ladder or hierarchy of intentions. To the ancient mind, this is the very meaning of the concept of organization and order. A cosmos – and, of course, *the* cosmos – is an organism, not in the sense of an unusually complicated industrial machine, but in the sense of a hierarchy of purposeful energies. (11)

Albert Einstein and Relativity

At the beginning of the 20th century Albert Einstein published two extraordinary papers which formed the foundation of a new understanding of the physical universe and led to a number of important experiments by other researchers that changed the face of science. "This exploration of the atomic and subatomic world brought scientists in contact with a strange and unexpected reality that shattered the assumptions of their worldview and forced them to think in entirely new ways."

> Einstein strongly believed in nature's inherent harmony, and throughout his scientific life his deepest concern was to find a unified foundation of physics. He began to move towards this goal by constructing a common framework for electrodynamics and mechanics, the two separate theories of classical physics. This framework is known as the special theory of relativity. It unified and completed the structure of classical physics, but at the same time it involved radical changes in the traditional concepts of space and time and thus undermined one of the foundations of the Newtonian world view. Ten years later Einstein proposed his general theory of relativity, in which the framework of the

> special theory is extended to include gravity. This is achieved by further drastic modifications of the concepts of space and time. (12)

It is widely acknowledged that Einstein was one of the most influential scientists in human history, whose ground-breaking work in the early decades of the 20th century forever reshaped our understanding of the nature of the universe:

> His fame rests on the two published theories and the astronomical observations of physical phenomena which confirm them. He overthrew a view of the universe that had endured for three centuries. In its place he constructed a new one: a profoundly strange and beautiful universe, where time is another dimension and where there is no standard of reference. A meter stick is only a meter while it is at rest. Move it and it becomes shorter, and the faster it is moved the shorter it becomes. Time is also relative in this Alice in Wonderland-like universe, time is no longer an unalterable absolute measure. In motion, each body has its own time which elapses more slowly as the body moves more rapidly. The ultimate barrier is the speed of light. No material object can go as fast; for as speed increases so does mass until – at the speed of light – mass become infinite and time stands still. Space-time itself is warped by matter in Einstein's universe. This warping or curving of space-time is gravity, and it can become so powerful that it crushes matter into a black hole, out of which nothing, not even light, can escape. (13)

Einstein's theories and discoveries were truly impressive and challenged the traditional scientific understanding of the nature of the universe. "The great edifice of classical physics developed by Isaac Newton, James Maxwell and so many others, which provided such seemingly effective explanations for the perceived realities of the world and fitted so well with common sense, was undermined by the discovery of relativity."

Einstein postulated that the speed of light was constant, that energy and matter are related by the formula $E=mc^2$, that space and time are not separate and independent but rather coexist as a four-dimensional continuum of "space-time," and that the primary laws of physics are exactly the same for all observers in relative motion. And, in a famous "thought experiment," he theorized that if one twin flew to a star 30 light-years away at close to the speed of light he would find that when he returned to earth his twin would be 30 years older than he was. Dr. Christian Wertenbaker explores the implications of these findings in the development of our current scientific understanding of reality:

> Relativity theory overturned the Newtonian picture of an unchanging background framework of the world, consisting of three perpendicular spatial dimensions, and an independent single dimension of time, flowing steadily from past to future, in which all events took place without affecting the structure of the framework. Special relativity dictated that space and time were interrelated, and that both were affected by relative motion, so that every moving object has its own spatio-temporal coordinates, length in the direction of motion being shortened in pro-

> portion to the speed of motion, and time being expanded, as viewed by an outside observer . . . The results are astounding, and amply confirmed nothing can travel faster than light, because if an object were to travel at light-speed, its thickness would be zero and its mass infinite. Energy and mass are convertible one into the other, because the energy provided to make an object move faster is reflected in an increase in its mass proportional to its velocity. And for light neither space nor time as we perceive them exist. This certainly suggests that light lives in a different dimension. General relativity further undermined the Newtonian framework by making the shape of space dependent on the masses within it, the distortion of space being the cause of gravitational effects. (14)

Physicist Fritjof Capra suggests that there are certain parallels between Einstein's theory of relativity and traditional Eastern spiritual teachings:

> In relativity theory, one of the most important developments has been the unification of space and time. Einstein recognized that space and time are not separate, that they are connected intimately and inseparably to form a four-dimensional continuum: space/time. A direct consequence of this recognition is the equivalence of mass and energy and the intrinsically dynamic nature of all subatomic phenomena. The fact that space and time are related so intimately implies that subatomic particles are dynamic patterns, that they are events rather than objects. So the role of space and time and the dynamic nature of the object studied are very closely related. In Buddhism, you discover exactly the same thing. In the Mahayana school, they have a notion of interpenetration of space and time, and they also say that objects are really events. (15)

Einstein's general theory of relativity, which describes the force of gravity and the large-scale space-time structure of the universe, is widely regarded as one of the greatest intellectual achievements in the history of science:

> Before 1915, space and time were thought of as a fixed arena in which events took place, but which was not affected by what happened in it. This was true even with the special theory of relativity. Bodies moved, forces attracted and repelled, but time and space simply continued, unaffected. It was natural to think that space and time went on forever. The situation, however, is quite different in the general theory of relativity. Space and time are now dynamic qualities: when a body moves, or forces act, it affects the curvature of space and time – and in turn the structure of space-time affects the way in which bodies move and forces act. Space and time not only affect but also are affected by everything that happens in the universe. Just as one cannot talk about events in the universe without the notions of space and time, so in general relativity it became meaningless to talk about space and time outside the limits of the universe. In the following decades this new understanding of space and time was to revolutionize our view of the universe. The old idea of an essentially unchanging

> universe that could have existed, and could continue to exist, forever was replaced by the notion of a dynamic, expanding universe that seemed to have begun a finite time ago, and that might end at a finite time in the future. (16)

Quantum Theory

Quantum theory was formulated in the first three decades of the 20^{th} century by an international group of outstanding physicists, many of whom were recognized for their seminal work by being awarded the Nobel Prize in Physics. The list of visionary physicists included such luminaries as Albert Einstein, Max Planck, Niels Bohr, Erwin Schrödinger, Werner Heisenberg, Paul Dirac, Louis de Broglie and Wolfgang Pauli:

> Even after the mathematical formulation of quantum theory was completed, its conceptual framework was by no means easy to accept. Its effect on the physicists' view of reality was truly shattering. The new physics necessitated profound changes in the concepts of space, time, matter, object, and cause and effect; and because these concepts are so fundamental to our way of experiencing the world, their transformation came as a great shock. To quote Heisenberg: "The violent reaction to the recent development of modern physics can only be understood when one realizes that here the foundations of physics have started moving; and that this motion has caused the feeling that the ground would be cut from science." In contrast to the mechanistic Cartesian view of the world, the world view emerging from quantum physics can be characterized by words like organic, holistic and ecological. It might also be called a systems view, in the sense of general systems theory. The universe is no longer seen as a machine, made up of a multitude of objects, but has to be pictured as one indivisible, dynamic whole whose parts are essentially interrelated and can be understood only as patterns of a cosmic process. (17)

The findings of quantum physics (also called quantum mechanics) revealed an underlying reality that is virtually incomprehensible, as it is in direct conflict with our common understanding of the world based on our normal sensory perceptions. Fritjof Capra: "Exploration of the atomic and subatomic world brought physicists at the beginning of the 20^{th} century in contact with a strange and unexpected reality. In their struggle to grasp this new reality, scientists became painfully aware that their basic concepts, their language, and their whole way of thinking were inadequate to describe atomic phenomena."

Four fundamental principles of quantum theory emerged in the early decades of the last century from both theoretical and experimental research in the field of subatomic physics: discrete quanta, particle/wave duality, uncertainty and probability, and non-local relationship of particles.

In 1900 German physicist Max Planck suggested that light, x-rays and other waves were not emitted at an arbitrary rate, but only in packets of specific energy levels or '*quanta*.' As well, he determined that each quantum had an amount of energy that was proportional to the frequency of the wave – the higher the wave frequency the higher the energy.

It became apparent that the movement of elementary particles is *discontinuous*, so that a particle such as an electron can go from one state to another without passing through intermediate states. Rather than a continuous movement from point A to point B, quantum objects move in a discrete "jump" or quantum from A to B without travelling through the intervening space. "Quantum physics challenges the concept of a deterministic trajectory of motion and causal continuity. If initial conditions do not forever determine an object's motion, if instead every time we observe there is a new beginning, then the world is creative at a fundamental level."

A second important discovery by the quantum physicists was that subatomic particles can exhibit several different properties (particle, wave or something in between) depending on the specific environment within which they exist and are subject to observation:

> Perhaps the most startling discovery of a reality beyond sensory perception is that all matter behaves both like particles and like waves. A particle, such as a grain of sand, occupies only one location at each moment of time. By contrast, a wave, such as a water wave, is spread out; it occupies many locations at once. All of our sensory experience with the world tells us that a material thing must be either a particle or a wave, but not both. However, experiments in the first half of the twentieth century conclusively showed that all matter has a "wave-particle duality," sometimes acting as a particle and sometimes acting as a wave. Evidently, our impression that solid matter can be localized, that it occupies only one position at a time, is erroneous. The reason that we have not noticed the "wavy" behavior of matter is because such behavior is pronounced only at the small sizes of atoms. At the relatively large sizes of our bodies and other objects that we can see and touch, the wavy behaviour of particles is only a tiny effect. But if we were subatomic in size, we would realize that we and all other objects do not exist at one place at a time but instead are spread out as a haze of simultaneous existences at many places at once. (18)

The intriguing finding of the apparent duality of the fundamental constituents of matter as both particles and waves (objects and processes) had significant implications for our understanding of nature: "Every cell, every molecule, every atom, every electromagnetic wave form is constantly changing. We perceive reality as a *constant state of existence*. Each apparent solid body is a coming together of billions and billions of atoms. Each atom (or electron, proton, etc.) has both wave and particle attributes, the particle attribute only showing itself when an actual *measurement* is made."

> The particle/wave duality lies at the heart of quantum mechanics. When investigators of the quanta of light demonstrated definitively the *particleness* of this phenomenon, it presented a great paradox (for a human mind's perspective on

> reality) that became clear over the opening decades of the 20th century, and led to the observation that the elementary particles of matter (photons, electrons, protons and neutrons) were, simultaneously in their nature, both particle-like and wave-like. Countless experiments have confirmed that, at an *atomic level*, our mass-based, external world of bodies, tables, mountains, planets and suns is composed of substances that are both particle-like and wave-like in their nature. Which aspect it is (particle or wave), appears to be dependent on the way questions and experiments are formulated relative to the atomic world. (19)

In 1927 Werner Heisenberg discovered that the observation of a subatomic particle such as an electron will influence and disturb the experimental situation and produce an *uncertainty* or imprecision in the results. For instance, the more accurately the experimenter tries to measure the position of a particle, the less accurately its momentum can be measured, and vice versa: "One can know at any one time where an electron is but not what it is doing, or what it is doing but not where it is."

Heisenberg's *uncertainty principle* undermines the classical notion of a strict determinism in nature. Louis de Broglie emphasized the implications of this radical idea: "We have had to abandon the traditional idea that phenomena, even elementary ones, are rigorously determined and exactly predictable, and to substitute for the rigid determinism of classical physics a more flexible conception, admitting that there exists at each instant in the evolution of elementary phenomena verifiable by us different eventualities concerning which it is only possible to estimate the relative probabilities." In this sense the laws of quantum physics are essentially *statistical*, and do not uniquely or precisely determine future events. Stephen Hawking stresses that uncertainty is a fundamental, inescapable property of the world:

> The uncertainty principle has profound implications for the way in which we view the world. Even after more than seventy years they have not been appreciated by many philosophers, and are still the subject of much controversy. The uncertainty principle signaled an end to a model of the universe that would be completely deterministic: one certainly cannot predict future events exactly if one cannot even measure the present state of the universe precisely! In general, quantum mechanics does not predict a single result for an observation. Instead it predicts a number of different possible outcomes and tells us how likely each of these is . . . Quantum mechanics therefore introduces an unavoidable element of unpredictability or randomness into science. Einstein objected to this very strongly, despite the important role he had played in the development of these ideas. Einstein never accepted that the universe was governed by chance; his feelings were summed up in his famous statement: "God does not play dice." (20)

Quantum theory also proposes that there is a connection between subatomic particles that transcends the ordinary limitations of space-time. A famous thought experiment by Albert Einstein, Boris Podolsky and Nathan Rosen in 1935 suggested that two entities, such as electrons, which combine to form a molecule and later separate, maintain a "non-local relationship" independent of distance. The term *entanglement* is sometimes used to describe this non-causal connection whereby under certain circumstances two particles remain one system even when separated by long distances.

> Another aspect of quantum theory that suggests other-dimensionality is seen in the non-local correlations between elementary particles. Elementary particles, including light, which have interacted at some point become "entangled"; their possibility wave-functions are combined, so that when they travel away from each other and are later detected, their properties are correlated. But, in the strange world of quantum logic, one cannot say that the particles had these specific correlated properties during their travels; only on measurement of one of them is a given property defined, and this measurement instantly results in a corresponding property being defined in the distant companion, at faster than light speed. Since the predecessors of all the particles in the universe were once interacting at the beginning of time, or the "big bang," all particles are connected in this way. Thus, in a sense, each part reflects the whole. (21)

The Implicate and Explicate Orders

Physicist David Bohm has proposed an intriguing model of the universe which challenges the traditional scientific view of reality:

> Bohm has elucidated the concept of the implicate order, an unseen totality underlying the external world of things and events (which he refers to as the explicate order). According to Bohm, all things are grounded in the implicate realm. This realm is in a deep sense inscrutable – for although it may be "intuitively" apprehended, it cannot be comprehended by the discursive mind . . . Implicit in Bohm's idea of the implicate order is the concept of flowing movement. All is flux and motion, says Bohm. This *holomovement*, this dynamism, is primary. It is only in the explicate order of our ordinary sensory experience that we divide this motion, sundering its purity into what eventually appears to be separate parts. These apparent divisions are illusory, however, since the implicate wholeness remains fundamental and indivisible. The entire function of the explicate order is to divide this world of oneness into apparent parts. It is our common-sense way of imposing order on the world. (22)

Bohm's presentation of the concept of an underlying implicate order essentially describes an undivided wholeness, flowing timelessly without borders, in which the totality of existence is enfolded within each region of space and time. "Whatever part or element we may abstract in thought, this still enfolds the whole and is therefore intrinsically related to the totality from which it has been abstracted. Thus, wholeness permeates all that is."

The explicate realm is the order of the world spread out or unfolded before us, while the implicate order is hidden or enfolded within the explicate domain. Thus the implicate order is more basic and primary and is the *plenum* that generates the explicate order. "The things that appear to our senses are derivative forms and their true meaning can be seen only when we consider the plenum in which they are generated and sustained, and into which they must ultimately vanish."

Bohm offers an analogy to describe the conceptual relationship between the explicate and implicate orders. In a television broadcast, a visual image is translated into the unseen or implicate medium as an electronic signal, which is then unfolded or decoded into the explicate order in the form of a corresponding image received by the television receiver.

The concept of an implicate order differs radically from the mechanistic model of classical physics, in which the emphasis is on separate components which produce a whole through the interaction of the distinct parts. Bohm elaborates: "When one works in terms of the implicate order, one begins with the undivided wholeness of the universe, and the task of science is to derive the parts through abstraction from the whole, explaining them as approximately separable, stable and recurrent, but externally related elements making up relatively autonomous sub-totalities, which are to be described in terms of an explicate order."

> What is primary, independently existent, and universal has to be expressed in terms of the implicate order. It is the implicate order that is autonomously active while the explicate order flows out of a law of the implicate order, so that it is secondary, derivative, and appropriate only in certain limited contexts . . . What, then, is the meaning of the appearance of the apparently independent self-existent 'manifest world' in the explicate order? Essentially, what is manifest is what can be held with a hand – something solid, tangible and visibly stable. The implicate order has its ground in the holomovement which is vast, rich, and in a state of unending flux of enfoldment and unfoldment, with laws most of which are only vaguely known, and which may even be ultimately unknowable in their totality. Thus it cannot be grasped as something solid, tangible and stable to the senses (or to our instruments). (23)

The concept of an implicate order also implies a multi-dimensional aspect to reality beyond the conventional space-time structure revealed by our senses. "Basically the implicate order has to be considered as a process of enfoldment and unfoldment in a higher-dimensional space. Only under certain conditions can this be simplified as a process of enfoldment and unfoldment in three dimensions."

> Quite generally, then, the implicate order has to be extended into a higher-dimensional reality. In principle this reality is one unbroken whole, including the entire universe with all its 'fields' and 'particles.' Thus we have to say that the holomovement enfolds and unfolds in a multidimensional order, the dimensionality of which is effectively infinite. However, relatively independent

> sub-totalities can generally be abstracted, which may be approximated as autonomous. Thus the principle of relative autonomy of sub-totalities is now seen to extend to the multidimensional order of reality. (24)

Bohm also proposes that the key to a fuller comprehension of the fundamental structures and dimensions of the universe, such as space and time, lies in the phenomenon of light. "To understand light we will have to understand the structure underlying time and space more deeply. You can see that these issues are related in the sense that light transcends the present structure of time and space and we will never understand it properly in that present structure."

> As an object approaches the speed of light, according to relativity, its internal space and time change, so that the clocks slow down relative to other objects, and the distance is shortened. You would find that the two ends of the light ray would have no time between them and no distance, so they would represent immediate contact. You could also say that from this point of view of present field theory, the fundamental fields are those of very high energy in which mass can be neglected, which would essentially be moving at the speed of light. Mass is a phenomenon of connecting light rays which go back and forth, sort of freezing them into a pattern. So matter, as it were, is condensed or frozen light. Light is not merely electromagnetic waves but in a general sense other kinds of waves that go at that speed. Therefore, all matter is a condensation of light into patterns moving back and forth at average speeds which are less than the speed of light. You could say that when we come to light we are coming to the fundamental activity in which existence has its ground, or at least coming close to it. (25)

Contemporary Cosmology

The concepts and experimental findings of relativity and quantum theory revolutionized the world of physics and completely altered our understanding of the nature of the universe. In the decades that followed, many of the initial cosmological ideas were confirmed, refined and in some cases significantly modified to fit new experimental evidence. Today there are exciting new ideas, theories and mathematical models which attempt to explain new research findings from universities and laboratories throughout the world.

An Invisible World Beyond Human Perception

Human beings are able to perceive only a very narrow band of the electromagnetic spectrum and are "blind" to a greater world beyond the limitations of sensory perception. The human eye can only detect a colour range from red light to violet light. But sophisticated instruments have detected radiation with wavelengths several *trillion* times longer than what the eye can see (ultra-long radio waves) and wavelengths *ten thousand trillion* times shorter than what the eye can perceive (ultra-high-energy gamma rays). "Modern science has certainly revealed a hidden cosmos not visible to our senses. For example, we now know that the universe is awash in 'colours' of light that cannot be seen with the eye: radio waves and x-rays and more. We were astonished to discover a whole zoo of astronomical objects previously invisible and unknown."

> More and more of what we know about the universe is undetected and undetectable by our bodies. What we see with our eyes, what we hear with our ears, what we feel with our fingertips, is only a tiny sliver of reality. Little by little, using artificial devices, we have uncovered a hidden reality. It is often a reality that violates common sense. It is often a reality that forces us to re-examine our most basic concepts of how the world works. And it is a reality that discounts the present moment and our immediate experience of the world. The most literal discovery of a world beyond human sensory perception was the finding that there is a vast amount of light not visible to the eye . . . The proportion of the full electromagnetic spectrum visible to the human eye is minuscule. All of these other wavelengths of light are constantly careening through space, flying past our bodies, and presenting strange pictures of the objects that made them – the glow of a warm desert at night, the radio emission of electrons spiraling in the Earth's magnetic field, the X-rays from magnetic storms on the sun. All phenomena invisible to our eyes. But our instruments can see them. (26)

Because of the fundamental limitations of our sensory apparatus we are also unable to perceive the rapidly changing nature of the apparently solid, stable forms of the physical world. "How can we relate, in a truly resonant way, to the quite incredible range and diversity of forms and energies in the universe? A human being is sensitive, via his body, to a very small portion of what is in motion all around us and through us. We are, materially and individually, *nothing* by comparison with the great Universe."

> In the macroscopic world, which we inhabit, there are trillions of measurements (interactions which move from potentiality to existence) every second. This could be the reason why we perceive the world around us as having *persistence* in its *particleness* (solidity). It is not that the quantum particle/wave duality has disappeared, but that the change from *potentiality* to *existence* is so rapid, occurring so many times per second, that it is well beyond our perceptual capacity . . . This is not difficult to imagine when we consider that the electron, while orbiting an atomic nucleus, is calculated as completing an orbit 40 million times per second! Speeds in the sub-atomic world are totally out of proportion to our perceptual abilities. The movement from potentiality to existence (from wave to particle) occurs so rapidly that the particleness or solidity persists in our macro-perception. (27)

Dark Energy and Dark Matter

Dark energy is a hypothetical form of mysterious energy that is believed to permeate all of space and constitutes 68% of the universe. Astronomers postulate that dark energy is responsible for the acceleration of the rate of expansion of the universe. Although space appears to be empty, in fact it is not. Stephen Hawking: "What we think of as 'empty' space cannot be completely empty because that would mean that all the fields, such as the gravitational and electro-magnetic fields, would have to be exactly zero. There must be a certain minimum amount of uncertainty or quantum fluctuations, in the value of the field."

> Theoretical physicists have several hypotheses for the identity of dark energy. It may be the energy of ghostly subatomic particles that can briefly appear out of nothing before annihilating and slipping back into the vacuum. According to quantum physics, empty space is a pandemonium of subatomic particles rushing about and then vanishing before they can be seen. Dark energy may also be associated with an hypothesized but as-yet-unobserved force field called the Higgs field, which is sometimes invoked to explain why certain kinds of matter have mass . . . On one thing most physicists agree. If the amount of dark energy in our universe were only a little bit different than what it actually is, then life could never have emerged. A little larger, and the universe would have accelerated so rapidly that matter in the young universe could never have pulled itself together to form stars and hence complex atoms made in stars. And, going into negative values of dark energy, a little smaller and the universe would have decelerated so rapidly that it would have re-collapsed before there was time to form even the simplest atoms. Here we have a fine example of fine-tuning: out of all the possible amounts of dark energy that our universe might have, the actual amount lies in the tiny sliver of the range that allows life. (28)

Dark matter composes some 27% of the universe. While dark energy repels, dark matter attracts. Dark matter releases no detectable energy but exerts a gravitational pull on all the visible matter in the universe. Astronomers have discovered that a vast "halo" of dark matter surrounds our Milky Way galaxy, confirming the reality of this invisible substance.

Black Holes

Albert Einstein first predicted the existence of black holes in 1916 with his general theory of relativity, but they were not discovered until 1971. Black holes are dark "voids" in space from which light cannot escape due to the overpowering force of gravity. A black hole is formed when a star becomes so hot that it uses up its fuel (usually hydrogen and helium), then begins to cool, contract and eventually collapse. Stephen Hawking describes how black holes come into existence and function:

> As the star contracts, the gravitational field at its surface gets stronger and the light cones get bent inward more. This makes it more difficult for light from the

> star to escape, and the light appears dimmer and redder to an observer at a distance. Eventually, when the star has shrunk to a certain critical radius, the gravitational field at the surface becomes so strong that the light cones are bent inward so much that light can no longer escape. According to the theory of relativity, nothing can travel faster than the speed of light. Thus, if light cannot escape, neither can anything else; everything is dragged back by the gravitational field. So one has a set of events, a region of space-time, from which it is not possible to escape to reach a distant observer. This region is what we now call a black hole. Its boundary is called the event horizon and it coincides with the paths of light rays that just fail to escape from the black hole. (29)

Because light cannot escape black holes they cannot be directly observed, but only inferred from their effects such as gravitational force. They are extremely dense and may range in size from relatively small to super-massive. Black holes "consume" gas and dust from the galaxy around them as they pull matter and energy into themselves and grow in size. Astronomers believe that the number of black holes in the universe is incalculable as they appear to be present in every observable galaxy throughout the universe. There is evidence that there is an enormous black hole with a mass of about a hundred thousand times that of the Sun, at the centre of our Milky Way galaxy. Black holes are an invisible, mysterious presence in the cosmos and a source of great speculation. Some have suggested that they are portals or "wormholes" to other dimensions in our universe or even alternative universes.

<u>String Theory</u>

String theory was first developed in the late 1960s and early 1970s. According to this theory, the basic objects of the universe are not particles occupying a single point in space, but entities that have a length but no other dimension, analogous to an infinitely thin piece of string. What were previously conceived as particles are now pictured as waves travelling along a string, much like waves on a vibrating kite string.

String theory is compatible with the concepts of both dark energy and dimensions beyond our conventional space-time matrix. It explains how extra dimensions can become enfolded or compressed into a size so much smaller than atoms that we do not detect them. The theory also supports the possibility of multiple universes. Alan Lightman: "String theory does not predict a unique universe, but a vast number of possible universes with different properties. It has been estimated that the 'string landscape' contains an almost infinite number of possible universes."

> String theory, too, predicts the possibility of the multiuniverse. Originally conceived in the late 1960s as a theory of the strong nuclear force but soon enlarged far beyond that ambition, string theory postulates that the smallest constituents of matter are not subatomic particles, like the electron, but extremely tiny one-dimensional "strings" of energy. These elementary strings can vibrate at different frequencies, like the strings of a violin, and the different modes of vibration cor-

> respond to different fundamental particles and forces. String theories typically require seven dimensions of space in addition to the usual three, which are compacted down to such small sizes that we never experience them, like a three-dimensional garden hose that appears as a one-dimensional line when seen from a great distance. There are, in fact, a vast number of ways that the extra dimensions in string theory can be folded up, a little like the many ways that a piece of paper can be folded up, and each of the different ways corresponds to a different universe with different physical properties. (30)

<u>Oscillating Universe</u>

Some physicists and astronomers have posited that the 'Big Bang' creation of the universe will eventually be followed by the opposite process, which they have termed the 'Big Crunch.' In this scenario, the eventual fate of the universe will be a reversal of the expansion, in which all matter falls back or rebounds on itself – analogous to a rubber band stretched to its limit and then re-leased. "The expansion of the universe started by the Big Bang will eventually slow down, and the gravitational pull of its matter will start the reverse process, with one possibility being that all the objects in the universe will collapse on themselves and create a single black hole – or 'singularity' – although what it will be a black hole *in* is unclear. Some scientists believe that this may then restart the cycle, with another bang and another universe."

There are parallels to this idea in Eastern spiritual teachings. For instance, traditional Buddhist cosmology describes an oscillating universe which evolves out of the emptiness of space and then eventually dissolves back into space. The whole cycle then repeats again and again. A similar concept appears in the cosmological teachings of Hinduism.

Einstein's theory of relativity allows for a model of the universe that is infinitely oscillating – a Big Bang, expansion and a Big Crunch – repeating endlessly:

> Einstein tells us what sort of evidence would answer the question of whether the universe will continue expanding or collapse and then expand again. It depends on how much matter there is in the universe. If there is more than a certain critical amount of matter, the universe will oscillate. If there is less than that amount of matter, then a single expansion will persist forever. If we try to measure how much matter there is in the universe, we get embroiled in a fascinating complicating factor. There seems too much, much more matter than we can see with our telescopes. We detect this dark matter through its gravitational attraction. We can detect how much gravitation there is in our region of the universe, and there is much more gravitation than you can account for with all the stars, all the galaxies, all the planets . . . The question is whether we now have evidence of enough dark matter to make the universe oscillate. The answer is no, not quite. But there is so much uncertainty as to how much dark matter there is, that there might possibly be enough. This is one of the most exciting areas of research today. (31)

Stephen Hawking discusses the origin and fate of the universe in the light of scientific discoveries about the Big Bang and the Big Crunch, and examines some of the fundamental questions arising from these findings:

> Einstein's general theory of relativity, on its own, predicted that space-time began at the big bang singularity and would come to an end either at the big crunch singularity (if the whole universe recollapsed), or at a singularity inside a black hole (if a local region, such as a star, were to collapse). Any matter that fell into the hole would be destroyed at the singularity, and only the gravitational effect of its mass would continue to be felt outside. On the other hand, when quantum effects were taken into account, it seemed that the mass or energy of the matter would eventually be returned to the rest of the universe, and that the black hole, along with any singularity inside it, would evaporate away and finally disappear. Could quantum mechanics have an equally dramatic effect on the big bang and big crunch singularities? What really happened during the very early or late stages of the universe, when gravitational fields are so strong that quantum effects cannot be ignored? Does the universe in fact have a beginning or an end? And if so, what are they like? (32)

Multiple Universes

Some scientists have hypothesized that there may be multiple universes, multiple space-time continua containing more than three dimensions: "The *same* fundamental principles from which the laws of nature derive, lead to many *different* self-consistent universes, with many different properties. Evidently the fundamental laws of nature do not pin down a single or unique universe. We may be living in one of a vast number of universes." This possibility led the Nobel-winning physicist Steven Weinberg to comment: "If the multi-universe idea is correct, the style of fundamental physics will be radically changed."

> Dramatic developments in cosmological findings and thought have led some of the world's premier physicists to propose that our universe is only one of an enormous number of universes, with wildly varying properties, and that some of the most basic features of our particular universe are mere accidents – random throws of the cosmic dice. In which case, there is no hope of ever explaining these features in terms of fundamental causes and principles. It is perhaps impossible to say how far apart different universes may be, or whether they exist simultaneously in time. But, as predicted by new theories in physics, the many different universes almost certainly have very different properties. Some may have stars and galaxies like ours. Some may not. Some may be finite in size. Some may have five dimensions, or seventeen. (33)

The possibility of multiple universes is supported by certain modern theories of physics, such as 'string theory' and 'eternal inflation.' For instance, one of the consequences of eternal inflation is that the original expanding universe spawns a multitude of new universes, in a neverending process. And the underlying principles of string theory are also compatible with multiple universes.

Unification of Relativity and Quantum Theory

One of the great challenges of modern physics has been the effort to construct a complete unified theory of everything in the universe. Such a theory would have to include a unification or reconciliation of the four primary forces of nature: gravity, the weak and strong nuclear forces, and electromagnetism. "The main difficulty in finding a theory that unifies gravity with the other forces is that general relativity is a 'classical' theory; that is, it does not incorporate the uncertainty principle of quantum mechanics. A necessary first step, therefore, is to combine general relativity with the uncertainty principle."

> We have made progress by finding partial theories that describe a limited range of happenings and by neglecting other effects or approximating them by certain numbers. Ultimately, however, one would hope to find a complete, consistent, unified theory that would include all these partial theories as approximations, and that did not need to be adjusted to fit the facts by picking the values of certain arbitrary numbers in the theory. The quest for such a theory is known as "the unification of physics." Einstein spent most of his later years unsuccessfully searching for a unified theory, but the time was not ripe: there were partial theories for gravity and the electromagnetic force, but very little was known about the nuclear forces. Moreover, Einstein refused to believe in the reality of quantum mechanics, despite the important role he had played in its development. Yet it seems that the uncertainty principle is a fundamental feature of the universe we live in. A successful unified theory must, therefore, necessarily incorporate this principle. (34)

There is a vigorous debate within the scientific community as to whether a complete unified theory will ever be achieved. One school of thought argues that such a theory will eventually be discovered, while others believe that there is no ultimate theory of the universe, only a progression of more and more accurate theories. Finally, there are those who hold that a complete theory is impossible since events cannot be predicted beyond a certain point, as they can occur in a random and arbitrary manner. Stephen Hawking reflects on this issue: "What would it mean if we actually did discover the ultimate theory of the universe? We could never be quite sure that we had indeed found the correct theory, since theories can't be proved. But if the theory was mathematically consistent and always gave predictions that agreed with observations, we could be reasonably confident that it was the right one." He also emphasizes that a complete, consistent unified theory is only the first step: "Our goal is a complete *understanding* of the events around us, and of our own existence."

Hawking proposes that a series of overlapping theories may be the most successful approach in understanding the nature of the universe:

> I believe there may not be any single formulation of the fundamental theory, any more than, as Gödel showed, one could formulate arithmetic in terms of a single set of axioms. Instead it may be like maps – you can't use a single map to describe the surface of the earth: you need at least two maps to cover every point. Each map is valid only in a limited region, but different maps will have a region of overlap. The collection of maps provides a complete description of the surface. Similarly, in physics it may be necessary to use different formulations in different situations, but two different formulations would agree in situations where they can both be applied. The whole collection of different formulations could be regarded a complete unified theory, though one that could not be expressed in terms of a single set of postulates. (35)

References

(1) Ravi Ravindra *Science and the Sacred* (Wheaton, Illinois: Quest Books, 2002), pp. 159-160.
(2) Jacob Needleman *A Sense of the Cosmos* (New York: E.P. Dutton & Co., 1975), pp. 16-17.
(3) Itzhak Bentov *Stalking the Wild Pendulum: On the Mechanics of Consciousness* (New York: Bantam Books, 1981), pp. 156-157.
(4) Arthur Zajonc (ed.) *The New Physics and Cosmology: Dialogues with the Dalai Lama* (New York: Oxford University Press, 2004), p. 176.
(5) David Bohm and F. David Peat *Science, Order and Creativity* (New York: Bantam Books, 1987), p. 199.
(6) David Bohm *Wholeness and the Implicate Order* (London: Routledge & Kegan Paul, 1980), p. 173.
(7) Jacob Needleman *The Indestructible Question* (London: Arkana, 1994), p. 24.
(8) David Bohm *Wholeness and the Implicate Order* (London: Routledge & Kegan Paul, 1980), p. 5.
(9) Gary Lachman *The Caretakers of the Cosmos* (Edinburgh: Floris Books, 2013), p. 87.
(10) George Ellis "Are There Limitations to Science?" *Parabola*, Summer 2005, p. 64.
(11) Jacob Needleman *A Sense of the Cosmos* (New York: E.P. Dutton & Co., 1975), p. 17.
(12) Fritjof Capra *The Turning Point* (New York: Simon and Schuster, 1982), p. 75.
(13) Walt Martin and Magda Ott (eds.) *The Cosmic View of Albert Einstein* (New York: Sterling, 2013), pp. xix-xx.
(14) Christian Wertenbaker *Man in the Cosmos* (United States of America: Codhill Press, 2012), pp. 104-105.
(15) Fritjof Capra "The Tao of Physics Revisited" in Ken Wilber (ed.) *The Holographic Paradigm and Other Paradoxes* (Boulder: Shambhala, 1982), p. 219.
(16) Stephen Hawking *A Brief History of Time* (New York: Bantam Books, 1998), pp. 34-35.
(17) Fritjof Capra *The Turning Point* (New York: Simon and Schuster, 1982), pp. 77-78.
(18) Alan Lightman *The Accidental Universe* (New York: Vintage Books, 2013), pp. 134-135.
(19) Keith Buzzell *Reflections on Gurdjieff's Whim* (Salt Lake City: Fifth Press, 2012), p. 238.
(20) Stephen Hawking *A Brief History of Time* (New York: Bantam Books, 1998), pp. 57-58.

(21) Christian Wertenbaker *Man in the Cosmos* (United States of America: Codhill Press, 2012), p. 54.
(22) Larry Dossey "Space, Time & Medicine" *ReVISION*, Vol. 5 No. 2, 1982, p. 59.
(23) David Bohm *Wholeness and the Implicate Order* (London: Routledge & Kegan Paul, 1980), pp. 185-186.
(24) David Bohm *Wholeness and the Implicate Order* (London: Routledge & Kegan Paul, 1980), p. 189.
(25) David Bohm "Of Matter and Meaning: The Super-Implicate Order" *ReVISION*, Vol. 6 No. 1, 1983. p. 36.
(26) Alan Lightman *The Accidental Universe* (New York: Vintage Books, 2013), pp. 128-132.
(27) Keith Buzzell *Reflections on Gurdjieff's Whim* (Salt Lake City: Fifth Press, 2012), p. 249.
(28) Alan Lightman *The Accidental Universe* (New York: Vintage Books, 2013), pp. 16-18.
(29) Stephen Hawking *A Brief History of Time* (New York: Bantam Books, 1998), p. 88.
(30) Alan Lightman *The Accidental Universe* (New York: Vintage Books, 2013), pp. 19-20.
(31) Arthur Zajonc (ed.) *The New Physics and Cosmology: Dialogues with the Dalai Lama* (New York: Oxford University Press, 2004), p. 181.
(32) Stephen Hawking *A Brief History of Time* (New York: Bantam Books, 1998), p. 181.
(33) Alan Lightman *The Accidental Universe* (New York: Vintage Books, 2013), pp. 4-5.
(34) Stephen Hawking *A Brief History of Time* (New York: Bantam Books, 1998), pp. 171-172.
(35) Stephen Hawking *A Brief History of Time* (New York: Bantam Books, 1998), pp. 182-183.