Science as Natural Philosophy and Finding Our Place in the Universe

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Dedicated to my grandchildren, the joy of my life

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PREFACE

> *Science is increasingly answering questions that used to be the province of Religion.* —**Stephen Hawking, physicist**

In 2020, the battle-cry during the COVID-19 pandemic was "follow the science". This universal collective mindset emerged because Science was deemed to be our only possible savior and reliable guide to lead us in a time of existential uncertainty. At that time, there were questions around the meaning of the laboratory testing, the populations that should be targeted, and the efficacy of a myriad of treatments. But ultimately there were no guarantees of any protection for our health and survival and the real limitations of Science were for the first time laid bare for all to see on a global scale. Yes, the idealized absolutes of Science offered us the greatest hope for a pathway forward in this time of trouble, but the biases and confounding perspectives of a frightened humanity did not provide resolute clarity to the direction we should take.

As a physician-scientist on the frontlines of the battle against this pandemic, the uncertainties of those tentative endeavors compelled me to once again reflect on the role of Science in society and in my life personally. For the ancients, Science was considered as Natural Philosophy with the purpose of providing a better understanding of the natural world and our place in the Universe. With the emergence of some powerful methods and tools during the Scientific Revolution of the 16th and 17th centuries, a myriad of new discoveries fueled the Industrial Revolution as a practical means to harness Nature for practically improving the human condition. However, in our quest for these new technologies there were also some surprising revelations born of discoveries in the modern era concerning the realities of the Universe that have had significant religious and philosophical implications.

The Scientific Revolution is thought to have really begun with the publication of Copernicus' heliocentric theory. In fact, the contemporary meaning of the word *revolution* as a radical and complete change is derived from his heretical notion that the Earth "revolved" around the Sun. That idea was indeed revolutionary in that it redefined our place in the Universe. No longer were the affairs of humanity considered as the centerpiece of all that was known. This Copernican revolution is one of the clearest hallmark examples of the possible impact that pure Science can have on our philosophical, religious, and spiritual perspectives and serves as a thematic thread interwoven in the discussions provided.

In this book, I explore the possible return of Science to a role as Natural Philosophy and a pathway to understanding our place in the Universe. In this journey, I draw heavily from my prior work (*Experiences in the Biocontinuum*) in which I searched for an explicit understanding of Life's foundational mechanism by utilizing a detailed and rigorous scientific approach. The insights of that endeavor and a lifetime of considering the roles of Science and Religion in comprehending the Universe have led me to the conclusions expressed in this current exploration. The content is heavily supported by frequent quotes by major thought leaders through history in the various areas of Science, Philosophy, Religion and the Arts. There is also some intentional repetition in the presentation of certain complex ideas from varying perspectives and in different chapters and sections in order to provide for better clarity. The references provided herein also serve as additional sources supporting the ideas and content of this current work.

CHAPTER 1

THE CENTER OF THE UNIVERSE

The Historical Perspective

Finally, we shall place the Sun himself at the Center of the Universe.
—Nicolaus Copernicus, priest, astronomer

On May 24^{th} in 1543, the Polish astronomer and Catholic canon cleric, Nicolaus Copernicus, lay writhing on his deathbed, partially paralyzed by a stroke he had suffered in the preceding winter. An advanced copy of his just published book entitled *De revolutionibus orbium coelestium* (On the Revolutions of the Celestial Spheres) was placed in his 70-year-old hands. The book contained the final conception and details of a radical idea that he had first proposed in 1514. However, for so long he had been much too afraid to ever publish his conclusions. Copernicus' notion that the planets revolved around the Sun rather than the Earth was in direct contradiction to two millennia of common wisdom and church doctrine. In this revolutionary Copernican heliocentric view, Earth and man's concerns were no longer the Center of the Universe. Strangely, Aristarchus of Samos had originally proposed the heliocentric concept around 300 BC without much attention. Nevertheless, in the world of Christendom such ideas could certainly result in Copernicus' execution as a heretic in the 16^{th} Century.

As he gazed on the pages of his life's work, Copernicus took his last breath and ironically passed into a central place in the history of Science. In fact, the Scientific Revolution as a major hallmark in the history of Western Civilization can arguably be said to have begun with this event. Even the modern meaning of the word "revolutionary" originates from a recognition that Copernicus' idea was a radical transformation from the norms of his time. Prior to this Copernican revolution, the accepted scientific perspective was consistent with Artistolean Greek and Ptolemaic cosmology that included Earth as the center of all the known Universe. However, at that time it was not Science in the modern sense of the word that considered questions like these as they related to the functioning of the natural world. Such deliberations were considered as a part of Natural Philosophy and emanating from reasoned thought rather than relying primarily on empirical evidence. In fact, it seemed obvious to the common observer that the planets and stars were moving around us in the night sky and that the earth stands fixed in space. After all, shouldn't humanity be at the center of everything anyway? Building on the Artistolean vision, Ptolemy developed a complex geometric system of dynamics as the foundation of an astronomy that explained the strange movement of the planets and stars based on the geocentric position. An arising Christendom embraced this viewpoint because of its consistency with the biblical creation narrative and the Old Testament citation that declared Joshua prayed until the Sun stood still. So clearly it was the Sun and not the Earth that was in motion.

Surprisingly, Copernicus' seemingly heretical conception did not initially create any great consternation with the papacy or scholars of the time. Possibly because the publishing editor, Osiander, included a preface to the book that asserted that the work was simply a hypothesis and a methodology for simplifying calculations as compared to the convoluted Ptolemaic system. Furthermore, he contended that this new Copernican proposition said nothing about the true causation of celestial motions.

In 1593 the Italian Dominican friar Giordano Bruno was put on trial for heresy and burned at the stake by the Roman Inquisition based on charges related to his cosmological and religious views. In addition to his acceptance of the Copernican model, he proposed that the stars were distant suns with their own planets and possibly Life. In his world-view, the Universe was considered infinite and therefore could not logically have a center. Obviously, Bruno's cosmology also informed his religious beliefs, particularly regarding the lack of a special position for humanity in creation.

The heliocentric theory really came to widespread public awareness after a notorious conflict with the Roman Catholic orthodoxy when Galilei Galileo defended the idea based on astronomical observations made with his new telescope device that was not available in Copernicus' time. Pope Urban VIII asked Galileo to objectively provide arguments for and against heliocentrism. In the now famous book, *Dialogue Concerning the Two Chief World Systems*, Galileo presented a biased perspective which depicted those arguing against the heliocentric view as being fools. This stance resulted in a scandal from which Galileo barely escaped execution and he was confined to house arrest for the rest of his life. In 1992, Pope John Paul II conceded that the Church had wrongly condemned Galileo and insightfully recognized that there is a formal distinction between the literal words of the Bible and their interpretation.

In the years subsequent to Galileo's controversial contentions, objective corroboration and validation of this heliocentric theory accumulated including considerably more accurate astronomical observations by Tyco Brahe and Johannes Kepler in the early 1600s. Additionally, Ferdinand Magellan had already circumnavigated the globe in 1519 and proved that the Earth was indeed a round sphere like the other planets. This emerging evidence allowed Isaac Newton to begin to wrest Earth from the center of the Universe and causally describe the dynamics of the both planetary motions and other earthly phenomena through a unified system of basic physical laws. Newton's real focus of study was concerning the force created by the center of gravity of a mass rather than a specific location for that center. Interestingly, Newton spent the majority of the latter years of his life studying theology and reinterpreting the scriptures from a uniquely heretical perspective.

Along this same time, the English seafaring traders had a great need for accurate astronomical measures to aid with navigation. Of particular importance was the designation of a specific fixed meridian from which longitude could be universally determined using chronometers. In 1674, King Charles II appointed a commission (including Newton's friend Christopher Wren) that led to the establishment of the Royal Observatory at Greenwich, London to designate Prime Meridian Time. John Flamsteed was appointed as Royal astronomer and for many Europeans at that time this location served as their practical center of focus and point of reference.

Subsequently, revolutionary thinkers such as Charles Darwin and Sigmund Freud extended the conception of Newtonian-like cause-effect mechanics to the scientific areas of biology and psychology and furthered the perception that humanity might not be the center of God's constant attention. In order to resolve this apparent inattentiveness of the deity to the affairs of humans, the well-known philosopher mathematician and scientist Pierre-Simon Laplace declared in 1814 that the Universe was like a great clockwork machine that had been set in motion by its detached creator and was solvable if we only knew all the factors.

> *If there were anything we could discover in Nature that would give us some special insight into the handiwork of God, it would have to be the final laws of Nature*. **—Steven Weinberg, Nobel physicist**

Eventually the mounting astronomical evidence compelled Christendom and the general scientific community into a common acceptance of the heliocentric view. However, a compromise view arose amongst some religious clerics that considered our solar system in the heart of the Milky Way Galaxy as the new center of God's concerns. It was only when there was a documented observation of a separate Andromeda Galaxy that the public began to understand the vastness of a Universe that might not have a real locational center as we know it. Over time, humankind began to acknowledge and even embrace their new diminished position with a sense of awe for the grandeur of our insignificance as a component of religious humility.

> *A religion…that stressed the magnificence of the Universe as revealed by modern Science, might be able to draw forth reserves of reverence and awe hardly tapped by the conventional faiths.* **—Carl Sagan, Astronomer**

When Edmund Hubble first demonstrated the redshift in the spectrum of observable light coming from distant galaxies, there was the further realization that the Universe was also expanding and therefore could potentially be traced back in time. With this revelation and through analyzing Albert Einstein's equations for General Relativity, Catholic priest and mathematician Georges Lemaître then concluded that there must be a beginning to the Universe. For many, this was again evidence of God's act of creation and seminal center of everything. Fred Hoyle who emphatically believed in a static Universe, disparagingly termed the origins of this expansion process as the "Big Bang". The final convincing evidence for a Big Bang came with the Nobel Prize winning discovery of the cosmic microwave background radiation by Arno Penzias and Robert Wilson. However, those radiation signals surprisingly came from all different directions and the idea of a central starting place was once again lost. Alan Guth's inflationary model describing the initial moments of Big Bang expansion on the surface of a bubble of curved space-time explained the ubiquitous radiation findings but also indicated that the notion of an actual positional center to the Universe did not make logical sense in this view of expanding time and space.

> *Look deep into nature, and then you will understand everything better.*
> **—Albert Einstein**

Despite the arising indications that there is no physical center, an innate driving desire for some position of grand relevance continued to stoke a common feeling that humankind's existence must play some central role in the Universe. In the beginning of the twentieth century, a new scientific perspective sometimes referred to as the "Copernican reversal" arose from the conclusions of relativity theory and quantum mechanics. While these fields of physics did not resolve anything regarding a universal center, there was definitely evidence that the observer of any phenomenal experience had a privileged position in determining how that reality was manifest. In fact, conceptual frameworks such as those considering the prospect of an underlying static ether or the exact position and momentum of a particle in space were no longer deemed valid. In light of these unusual findings from the physical sciences, many modern thinkers began to reimagine the true nature of reality, especially drawing heavily on the ancient ideas found in eastern mysticism.

A Different Kind of Center

Scientists have become the bearers of the torch of discovery in our quest for knowledge. **—Stephen Hawking, physicist**

Early Greece was the cradle of critical thinking and reasoning based on employing a combination of observations and logical deductions. There were two great schools of thought that emerged in that ancient period that sought to understand the natural workings of the Universe beyond the established mythologies of the time. Natural Philosophy had its origins with Anaximander, Democritus and their followers who attempted to explain phenomenal dynamics based on more fundamental and naturalistic causes. For instance, in considering the paradox of Zeno, Democritus concluded that the Universe had a basic granular or bit-like nature and was the first to develop the concept of the indivisible atom. This perspective bounded the concepts of infinity and considered all phenomena as the product of the interactions of these atomic particles. By stark contrast, Aristotle adopted the view that a Final Causation was an inherent property of all matter, living and nonliving. He concluded that this innate causal force ultimately determined the path of all dynamics. This teleological based perspective was undoubtedly influenced by Aristotle's detailed study of biology with its seemingly purposeful nature. Thus, through the Artistolean methodology the causality of phenomena and the true nature of reality could be discovered solely by a process of reasoning with end-purposes in mind and without a heavy reliance on observational evidences.

Unfortunately, the Artistolean form of Natural Philosophy dominated the path of Science for most of the history of western civilization. This ascendancy was probably due in part to the fact that the naturalistic approach of Anaximander and Democritus implicitly required specialized techniques and instruments for precision observations that were not available until the time of the Renaissance craftsman. But most importantly, Aristotle's perspective of a preordained causality was in consilience with most theological ideologies that championed the role of the creator in determining the detailed outcomes of the Universe. Naturally, humankind was judged as the primary recipient of these conditions as the central focus of a divine creation and therefore held a privileged position. And since humans lived on Earth then certainly that location should be considered the Center of the Universe.

Even before Aristotle, the Center of the Universe was often considered by many cultures as some kind of physical location that usually had some religious significance. For the Jewish nation, Jerusalem and the promised land of Canaan was the Holy Land. For Islam it was Mecca. For the Greeks, the gods lived on Mount Olympus. For the Aztecs, Teotihuacan was considered their universal center as connected to the deity.

Today, modern physics and cosmology does not provide for any conception of a Center of the Universe. Furthermore, neither biology nor the psychological sciences places humanity in a "crown of creation" position. In fact, such notions are really considered by scientists as an archaic relic of our past mythologies and antithetical to our current scientific understanding of the Universe. This view is particularly true if the center is considered as an exact position in space and the term Universe refers solely to the physical infrastructure of solar systems and galaxies.

Considering alternative non-positional definitions for the term "Center and Universe", we know from the American Heritage Dictionary that a center is otherwise abstractly defined as the point from which all activities or processes are directed or emanate. As a verb it is the focal cause or central directive. Likewise, the term Universe can mean more than just a physical entity with a location or position in space but can also be applied to indicate the total realm of existence, experience and knowledge. For instance, there is also the universe of ideas and the sphere of experiences, past and present. Such realms are generally observer dependent and generated through intentionality whereby the process for the origination of this type of universe is central to its actualization. This observer-oriented conception is foundationally a different kind of center in a realm that is also a different kind of space known as the biological continuum or biocontinuum.

Reality is therefore as much in the connection (relationship) as in the distinction between the open system and its environment.
—Edgar Morin, complexity theorist

The biocontinuum is considered a coherent information space that includes everything that could have a potential experiential interaction and information exchange with the living system processes which are in turn responsible for generating, actualizing, and sustaining the conditions of the space. Therefore, the biocontinuum space includes all possible energy, material and informational exchanges as well as communiques originating from within or external to the usual considered boundaries of the organism. As a continuum, there is a no real distinction between the living system and its adjacent environment since the considered space includes everything within the experiential realm of the life processes. This scope also includes the organism's experience of its own internal state. The inseparability of the open living system from its environment, particularly with regards to exchanges in information, is becoming a common notion in modern theoretical constructs where the systems themselves are considered as an intrinsic part of the environment as a whole.

The main character of any living system is openness.
—Ilya Prigogine, Nobel chemist

The major advantage of this conceptualization of the biocontinuum as a coherent information space including the entirety of the experiential realm is that it allows for the mathematical formulation of the possible states of the space in terms of Shannon information. This information is first captured with perception and then differentiated and deconstructed to meaning as the biological process of knowledge acquisition progresses. With further ongoing experiences, a Bayesian process of updating through acquired knowledge can also be incorporated. This information-based biocontinuum framework allows us to axiomatically track the general process of experience as the key element in the emergence of Life. The specifics of the formulation of this framework will be discussed in greater detail in Chapters 4 and 5.

Perhaps, a new kind of Center of the Universe can be considered as the point of origination of all experiential existence and knowledge. From that point of origin, the acquisition of knowledge, the practice of Science and our conception of the Universe can be examined from a uniquely biocentric perspective. This path will then be a new means to understanding with a possible reconciliation of scientific and religious ways of thinking.

Why Do We Need a New Way of Understanding?

I am against Religion because it teaches us to be satisfied with not understanding the world. **—Richard Dawkins, evolutionary biologist**

As previously noted, the Greek way of scientific thinking lasted for thousands of years and dominated all thought throughout the Dark Ages and into the Renaissance period. While the term Natural Philosophy is no longer used to designate the accepted methodology for understanding Nature, its expression as a philosophy reflects the fact that it was a competing worldview for much of our history. As a philosophy, all knowledge acquisition prior to the Scientific Revolution depended less on 3rd party objective empirical evidences and relied more heavily on reasoning and logical deduction from assumed universal principles that were mostly handed down by Aristotle. The salient difference in this approach from the practices of modern Science mainly stems from the ancient's lack of sophisticated and accurate tools for observation.

During the Renaissance, craftsman, engineers and artisans began developing many new tools for measurement and construction because of the increasing need for precision in their work building large structures such as cathedrals. Additionally, the building of multistage industrial systems such as windmills and water turbines to generate a specified action of work helped shape our understanding of how causal chains are mechanically produced from connecting the individual components. At that time, Galileo Galilei also emerged to become what was probably our first modern scientist. Galileo, Newton and others began to formulate generalized mathematical descriptions of simple physical phenomena based on more accurate observations using instruments such as timepieces, prisms, and telescopes in what was the beginning of our modern Scientific Method. It was the unwavering requirement of this new method for objective proof through testing that differentiated Science as a practical endeavor. In this process, the natural world was considered as the ultimate arbiter and judge of truth from which there could be little or no debate. Today, this empirical testing of a theory is still the aspect of the modern Scientific Method that is considered the hallmark that separates it from philosophy and theology. The terminology "Natural Philosophy" was later changed in the 19th century by William Whewell to the Latin scientia, meaning knowledge, because of the realization that Science as a discipline was really about getting to objectively know the world and how it works without the encumberments of philosophical considerations.

The human foot is a masterpiece of engineering and a work of art.
—Leonardo da Vinci, renaissance thinker

This practical approach to knowledge acquisition opened up the applied methodology of Science to be used as a means for improving the human condition. As such, it also became a bridge between the world of the craftsman-artisan who depended on tools and the academic view of the intellegencia who championed purely deductive thinking. Leonardo da Vinci is an example of a Renaissance artisan who began to bring these two approaches of thinking together. His passion for art and architecture uniquely intersected with his mechanical acumen. Eventually, the practice of Science, with its success in causal prediction and precision, became synonymous with technological development. Science became the key in advancing the Industrial Revolution of the past two centuries and the subsequent nuclear, space, and information ages and forthcoming biomedical revolution.

Along this trek towards greater technological development, we have lost the original intent of Natural Philosophy as a means to help us truly understand our place in the Universe and as a way for balancing the relative importance of inductive information and deductive reasoning. This balancing is once again particularly important as we are now reaching the limits of our observational capabilities and are frequently relying on the internal mathematical consistency of our theories in providing an understanding beyond what our senses and instruments offer in direct experimental experience. While modern Science provides us with a clear methodology for understanding how things work from a causal perspective, it is ultimately the lens of the individual observer's experience through which we actually get to know the world holistically. And the serious limitations and paradoxes of that experiential process in the practice of the Scientific Method have repeated emerged in a variety of areas of study. From the self-referential enigma of Gödel's Incompleteness Theorem to the Heisenberg Uncertainty Principle of Quantum Theory, the position of the observer has been at the heart of a disconnection between Science and an understanding of our Universe. The importance of this unique observer's role is also critical in comprehending such scientific ideas as the 2nd Law of Thermodynamics, Special and General Relativity, Information Theory, and the Anthropic Principle. According to modern physics, so central is the perspective of the observer in the determination of perceived reality that the renowned physicist John Archibald Wheeler resolved that we really live in a participatory Universe. This articulated relationship with the Universe should be the basis for a new understanding and a novel central position for the experiential processes of living systems from which the entirety of known reality emanates and the created becomes the creator.

CHAPTER 2

THE NATURE OF EXPERIENTIAL REALITY

The Foundations of Reality

From those early days of the Greek Philosophers it was recognized that if there is to be a discovery of absolute truth then there must first be an agreement on the source of reality. Idealism, as developed by Plato, asserts that reality is derived from idealized mental or virtual constructs. For instance, a truly perfect geometric circle does not actually exist in Nature but the idealized mental construct for such a circle is the reference point for our thinking and communicating about the reality of such objects in the world. Plato's famous allegory of people chained in a cave with their backs to the entrance that only ever know of the projected shadows of objects on the wall also highlights the role of the individual's experiential condition on the perception and understanding of reality. By contrast in the extreme, Materialism proposes that the actual physical objects are the only true reality and that these objects exist objectively outside of our experience of them. In the 17th Century, Descartes was concerned with reconciling the subjective processes of the mind with the objective analyses of Science and proposed a mind-body dualism in the determination of reality.

> *If a man will begin with certainties, he shall end in doubts; but if he will be content to begin with doubts, he shall end in certainties.*
> **—Sir Francis Bacon, philosopher**

By the time of the 19th Century, influential thinkers such as Sir Francis Bacon, John Locke and David Hume had won the soul of Science by considering empiricism as the grounding principle for the only reality from which we could discover scientific truths. Based on purely objective empirical evidences, Science became more concerned with describing the workings of Nature as "how" questions rather than philosophical conceptions or the "why" questions. Knowing how things work was particularly critical at this point in our history as we attempted to harness the mechanics of the natural world for the burgeoning Industrial Revolution. However, using a strict induction procedure from empirical observations as a basis for reality was inherently fraught with some variability and inconsistency in determinations. By definition, empirical evidence is based on an individual's observations and experiences. Consequently, the multitude of observations events of various individuals were coalesced into more generalized deduced theories concerning how things worked. These theories were then viewed as simplified approximations to the conditions of reality and the mechanics of phenomena that could be applied broadly. While these determinations often carried the illusion of dogmatic certainty, they were really subject to the idiosyncratic conditions under which the evidences were procured and it was not uncommon for theories to change significantly.

As the investigations of Science became more detailed and complex, such as in the case of Einsteinian relativity, quantum theory, and Big Bang cosmology, some of the theories had a metaphysical leaning that challenged our conventional notions of scientific reality. Is Schrödinger's cat dead or alive? Is there really a multi-verse? Is string theory a valid hypothesis? At the heart of this trending shift in the paradigm of Science is the role of the observer. The modern approach to Science tries to reconcile all of these perspectives with new considerations for the origins of objective and subjective knowledge. But unfortunately, the boundaries between the reality of the physical world and the observer, which is also a part of the physical Universe, are still blurred.

In the prior chapter, we charted our evolution in thinking about the position and role of humanity in the Universe. Through this historical journey in Science, researchers have learned much about the structure and character of reality as seen from our role as observer/participant. But what are the salient lessons from physics, mathematics and biology? Does the evidence for a central position for the observer represent a real disconnection between objective Science as traditionally practiced and our true comprehension of natural phenomena? Moreover, do these lessons call us to return to the original intent of Science as Natural Philosophy for understanding our place in the Universe? In this chapter, we will use these lessons to begin to explore some of these questions in greater depth in order to find our way on a new path forward.

Man has to awaken to wonder - and so perhaps do peoples. Science is a way of sending him to sleep again. **—Ludwig Wittgenstein, philosopher**

Lessons from Physics

Einstein's Relativistic Thinking

In his famous "miracle year" of 1905, a young Albert Einstein was fascinated with the long forgotten Galilean principle connecting conditions of inertia with the relativity of dynamics. Galileo first described this principle in 1632 in which he noted that the laws of motion are relative to the inertial frame of reference of the observer. Stated more simply, it is impossible for an observer to determine if a seemingly stationary object was actually moving or at rest without some outside source of reference. In the Special Theory of Relativity Theory, Einstein postulated that the laws of physics are invariant in all inertial systems in uniform motion and that only the speed of light is constant and independent of its emitting source. To reconcile these propositions, time has to be considered as a variable like all other dimensions. Therefore, as the observer moves in space, experienced events could occur at times that differ from another observer moving at another speed or in another direction. Prior to that seminal work, the frame of reference for all existing natural phenomena was the absolute ether space of Newton.

Einstein also suggested that time and space are as much a part of the physical world as matter and energy and are interwoven into a unified continuum that cannot be separated. Furthermore, the conditions of space-time can change based on the frame of reference of the observer. In fact, there is no observer independent structure of space-time. This space-time structure also results in a relativity of simultaneity which is a concept in physics first consider by Henri Poincaré in 1900 and later adopted as a central idea in Special Relativity by Einstein. Because the speed of light is constant, an observer's momentary experience of spatially separated events does not mean that those events occurred at the same instance in local time. Therefore, any notion that there is an objective simultaneity of events is meaningless. And for any individual experiential frame of reference, there is no global or universal time. For example, any current observations of the stars in the night sky are really the result of events that happened light-years ago. Because the observer's distance to each individual star may differ, there is no synchrony in the timing of the emission of those rays of starlight. Additionally, gravitational forces that distort the space-time continuum can also alter when events occur. Hence, all our present perceptions and experiences really spans the course of both time and space.

When a new quality is manifested, something which doesn't have a name, something which you can't recognize, or more exactly you recognize as something which you can't identify, then that is exactly the moment of Becoming. **—Georg Wilhelm Friedrich Hegel, philosopher**

For any individual observer, there is a clear past and future in time. The past exist as a memory of coalesced phenomenal occurrences and the future holds an imagined temporal position of events yet to come. Both are established mental constructs. However, as described above, the present as experienced is not a bounded occasion in time and space. The present has a unique locus which Carlo Rovelli calls the expanded or extended present that is determined by the interwoven structure of space-time and the observer's frame of reference. Science is not so much about discovering the reality of "things" as it is about understanding their dynamics and interactions. Rovelli suggests that we can consider reality as a complex web of "*becoming"* that is dependent on relative relational interactions. This process of becoming is reminiscent of the Buddhist holistic concept of a co-dependent arising of all things in the creation of the Universe. In this way, we can think of the reality of the present as a continuous becoming that is the "now" created out of the past and thrust into the future. The work of Einstein was a definitive philosophical sea change from the typical concept of phenomenal dynamics as driven by direct forces and mechanistic causality as codified in the Newtonian laws of physics. Coincidentally, this relativistic shift in perspective was also consistent with the ancient Buddhist notions of impermanence as the essential nature of all things. The relativistic concepts of simultaneity and the extended present as a process of becoming are also critical to exploring the ideas of the interconnectedness of the Universe across both time and space in subsequent chapters.

There is nothing permanent except change. No man ever steps in the same river twice, for it's not the same river and he's not the same man.
—Heraclitus, ancient Greek philosopher

Even before Einstein, the rederivation of phenomena by Lagrange, Hamilton and others had emphasized the identification of the right action functional driven by changing energy balances as a more general framework for analyzing dynamics. If a mathematical construct correctly describes the energy accounting of a system then the path for dynamic actions naturally flows from this background assemblage. With the curvature of space-time in general relativity, the movement of objects in gravity no longer had to depend on the "action at a distance" of Newtonian gravity. Dynamics in this space-time geometry flowed according to the natural shape of the mass induced gradient curvature of space-time as an expected action. While the dynamics of relativity organize the context of experience for the observer, it is unlikely that the relativity of reality stops with the basic experience of the dimensions of time, space and gravity. Obviously, other observable metrics such as colors or textures are to some degree similarly relative to the observer. Ask any colorblind person. Perhaps, all perceived information that is dependent on the experiential conditions of the observer is also relative.

Heisenberg Uncertainty and Schrödinger's Cat

What we observe is not Nature itself, but Nature exposed to our method of questioning. **—Werner Heisenberg, Nobel physicist**

Quantum mechanics is the field of study concerned with physical processes involving extremely small particles such as photons, protons and electrons. It was first developed as a field of study in the early part of the 20^{th} Century stemming from Max Planck's work in solving the black-body radiation problem intended for understanding the physics of the new invention of the light bulb. According to Planck, the energy for the action of a particle (E) is proportional to its frequency (ν) as multiplied by h (Planck's constant).

$$E = hv$$

Initially there was some trepidation amongst physicists with this result in the realization that the frequency is a discrete quantity, whereas Newtonian mechanics assumes that all energy transactions occur as a continuous process. Thus, the discretely quantized behaviors of these particles seem to contradict some basic tenets of classical physics.

Because of the revolutionary implications of the theory regarding the basic nature of physical reality, Planck insisted that he had only discovered a mathematical trick to calculate the absorption and emission of radiation. However, in 1905 Albert Einstein used Planck's quantum method to explain the photoelectric effect for which he won the 1921 Nobel Prize in Physics. Einstein theorized that when light hits the surface of an object, energy is transferred as quantized packets of energy known as photons. This practical application of the strange theory brought immediate credibility to the quantum approach.

Ironically, in subsequent years Einstein was probably the most fervent opponent to the radical notions concerning the nature of reality suggested by quantum theory. In response to the conundrum, Schrödinger's wave function equation was formulated to describe the deterministic behavior of particles acting as both waves and particles. However, from these developments it appeared that the actual experimental process of observation in itself always disturbs the condition of the particle and provides an intrinsic degree of uncertainty in knowing its true state. This conditional uncertainty left the state of the particle in limbo or superposition until it is actual experienced and measured. This perplexing scenario is the basis of the Heisenberg Uncertainty Principle first introduced by the German physicist Werner Heisenberg in 1927. From his proposition, quantum uncertainty became quantitatively characterized by a determined probability distribution of measurement outcomes during the observation of a particle's state. Moreover, the very act of measurement converts quantum indefiniteness into the classical definitive.

To observe is to disturb, for observation breaks the wholeness of Nature.
—Fred Alan Wolf, physicist, author

But uncertain to whom? To God? To the Universe? Or just to the scientists trying to make the measure? The term uncertainty denotes a lack of knowledge about the true state of the particles and suggests that these particle states exist only as potentials within a spectrum of probabilities until they are actualized in the experiential process. In fact, "indeterminacy" (unbestimmtheit in German) was the original name that Heisenberg used to describe his principle indicating the "unknowability" (ungenauigkeit in German) of the particle state before it is observed. The difference between uncertainty and indeterminacy is the difference between not knowing because it hasn't been definitively measured and not knowing because it can't be determined within the act of measuring. And through this act of measuring or observation, the dimensions of the particle are actualized and interpreted. Therefore, the principle's indeterminacy really describes the ontological physical ambiguity concerning the particle's state and posits that even its exact position and momentum can only be established within the error limits of human observational knowability. Of course, that limit is the quantum of the light photon, which is really our best direct tool for probing the subatomic levels.

A phenomenon is only a phenomenon if it is an observed phenomenon.
—John Archibald Wheeler, physicist

To resolve these perplexing considerations, the "Copenhagen" interpretation of quantum mechanics was devised by Niels Bohr and Werner Heisenberg to provide a new understanding of physical reality. According to their interpretation, physical systems do not have definite properties prior to being actually observed and the methods of quantum mechanics can only predict the probabilities that the measurements will produce certain results. Accordingly, reality only exists as a potential until it is actualized by the experiential process. Therefore, it appears that the perception of reality is implicitly a fundamentally active participatory process by the observer as noted by John Archibald Wheeler.

When large numbers of particles are assembled together, their wave interferences tend to cancel each other out in a way that results in their perception as tangible objects. This is akin to many pebbles hitting the pond at the same time and their ripples cancelling each other out to produce the appearance of still water. Fortunately, the contents of our experiences have considerable inter-subjective agreement, particularly at the macroscopic level. This consilience is likely due to the similarity in our biologic constitution. For instance, we cannot be certain that we all experience the same blue color but we generally agree on which shading is designated blue because at a very basic level the signal created by the varying excitation of a cluster of rhodopsin molecules caused by the differing photon frequencies of assorted colors of light are the same for all humans. This distinction may be quite different for other phyla or even other species of organisms.

The more we know about our Universe, the more difficult it becomes to believe in determinism. **—Ilya Prigogine, Nobel chemist**

Einstein rejected the viewpoint of the Copenhagen interpretation because it lacked clear deterministic causality. Even the alternative explanation of a collapse of the wave function upon measurement seemed somewhat arbitrary. Other notable scientists also had problems with the non-deterministic nature of quantum mechanics and argued that the theory was incomplete and that there must be an underlying structure with "hidden variables" that were yet unknown to Science. Great thinkers such as Louis de Broglie and David Bohm joined Einstein in the quest to find a new theory which included this hidden framework of causation. But every attempt at deterministic resolution included the implication of strange unseen causal effects or mysterious explanations such as unknowable parallel universes or intermediary concealed variables that all seemed to be somewhat contrived.

This does not mean that the Universe is absurd or meaningless, only that an understanding of its existence and properties lies outside the usual categories of rational human thought. **—Paul Davies, physicist, writer**

In response to the uncertainty conundrum, Erwin Schrödinger proposed his classic thought experiment in quantum mechanics in which a cat is imagined as being sealed in an enclosed box with a poison that will be released when a radioactive source randomly emits radiation. Schrödinger argued that is absurd to consider that there is an absolute indeterminacy as to whether the cat is alive or dead before it is observed. However, in the standard Copenhagen interpretation, the cat is considered to be simultaneously both dead and alive until the box is opened and the cat is actually observed to determine it state. Prior to the observation the cat's condition is indeterminate and is said to be in a state of quantum superposition. The act of observation precipitates the final condition by collapsing the quantum wave probability equation and actualizes the state of reality. Therefore, the uncertainty within the Heisenberg Principle is not only due to an epistemic lack of information but also represents the degree of ontological equivocality of the state of things. The problem is that the Copenhagen view disrupts the causal entailment of natural phenomena because considering states as "possibles" fails the basic logic of the Principles of Noncontradiction and the Excluded Middle. In a solution for this noncausal context, Max Born interpreted the Schrödinger wave function as simply a probabilistic description of our knowledge for subatomic observations for which he won the Nobel Prize in 1954.

The Universe is under no obligation to make sense to you.
—Neil deGrasse Tyson, physicist, author

This crisis concerning determinism in Science resulted in great debates between Einstein and Bohr concerning the fundamental nature of experiential reality. During one debate, Einstein famously stated "God does not play dice" to which Bohr replied "quit telling God what to do". Since the time of the Fifth Solvay Congress, when Max Born, Werner Heisenberg and Niels Bohr declared that quantum mechanics was a complete theory, the debate has continued to this day. Some thought experiments such as the Einstein, Podolsky, Rosen paradox and more recently Wheeler's delayed-choice "gedankenexperiment" proposal have famously highlighted the logical conundrum of a violation of some of the basic principles of causality