

Article

Consciousness, Cosmology & the Meaning of Life (Part I)

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ABSTRACT

In this article, I strive to answer the question whether life is just a meaningless rash of complexity – a planetary surface growth in a physical universe, which cares not a dot for biological or conscious survival, and in which black holes and disintegrating galaxies hold the ultimate fate of all. Conscious beings are launched by their very existence on a quest to discover the essential meaning in life that makes sense of the entire process. Effectively, the world is divided between two complementary realms, the subjective realm of conscious experience and the objective realm of physical existence which we access indirectly through the former, although we recognize physical existence, and with it our biological bodies and brains, to be essential to the existence of our conscious mental states. Central in this resolution of our sense of meaning and purpose is preserving the diversity of life and the robustness of the biosphere, so that that the future generations of life and humanity can prosper and further expand the vistas of conscious experience.

Part I of this two-part article includes: The Existential Dilemma; The Paradox of Consciousness; Free-will, Determinism and Accountability; Quantum Reality and the Conscious Observer; A Perfect Storm at the Edge of Chaos; Enter the Holographic Brain; Origin Myths and Apocalyptic Allegories; Coming to Terms with the Cosmological Universe.

Keywords: Consciousness, cosmology, meaning of life, quantum reality, free will, holographic.

The Existential Dilemma

Conscious beings are launched by their very existence on a quest to discover the essential meaning in life that makes sense of the entire process. It's the one thing we all want to know - the central core truth of reality - before we escape the mortal coil and pass on.

There are many depictions of the existential dilemma, echoing through philosophy, novels, art music and theatre. Existentialism itself is an attempt to form a philosophy centered on this dilemma, emphasizing the existence of the individual person, as a free and responsible agent, determining their own development, through acts of the will. Jean Paul Sartre claimed that a central proposition of Existentialism is that existence precedes essence, which means that the most important consideration for individuals is that they are individuals - independently acting and responsible, conscious beings (existence) - rather than what labels, roles, or other

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preconceived categories the individuals fit (essence). Thus, human beings, through their own consciousness, create their own values and determine a meaning to their life.

Many religious people believe in an ordered cosmos ruled by God, with the single purpose of testing human moral obedience in a cosmological trial ending in a day of judgment. All the great monotheistic religions preach that we must obey God's commands if we seek eternal life in heaven and that those who fall into sin will be tormented forever in the fires of hell. Nor do we have the right to even assess whether these claims are true or false, for such religion also demands that we believe, regardless of the evidence or lack of it, either as the foundation of affirmative religious faith, or oppressively as in Islam, under pain of death for apostasy. Centrally this is a moral cosmology in which conscious experience is predominant in fantastic visions of paradise and hell taking precedence over the veridical reality of nature and the real world around us.

Doctrines claiming the literal truth of every word in the Bible and Quran lead to an inability to accept the evidence of the natural and physical world. Rejecting the clear evidence that the universe, the Earth and life itself are billions of years old, many cling to the notion that the universe was made literally in six days, as in the sabbatical creation, so is no older than the 4000 years ago, when the events of Genesis are assumed to have occurred. Those Christians whose scientific experience leads them to have to acknowledge the evidence of the universe's actual age, unable to escape the convictions of their religious beliefs, attempt to paste the literal 'revealed truth' of the scripture into the scientific view, so that the same literal Old Testament deity has instead made the vast ancient physical universe, we have discovered much later in the scientific age, but then claim has much more recently, manifested again to 'give' human kind the knowledge of good and evil and 'living souls', so that we still have to live out the morally imperative eschatology regardless.

Others of a more honest predisposition may conclude there is no preferential rhyme or reason to existence in the physical world and that life is, just as we see it, a round of tooth and claw, as generation upon generation struggles in the survival of the fittest, amid the endless attrition of entropy and mutational change, most ominously and succinctly expressed by Bertrand Russell:

Such in outline, but even more purposeless, more devoid of meaning is the world which science presents for our belief. Amid such a world, if anywhere, our ideals henceforward must find a home. That man is the product of causes that had no prevision of the end they were achieving; that his origin, his growth, his hopes and fears, his loves and his beliefs, are but the outcome of accidental collocations of atoms; that no fire, no heroism, no intensity of thought and feeling, can preserve an individual life beyond the grave, that all the labours of the ages, all the devotion, all the inspirations, all the noon-day brightness of human genius, are destined to extinction in the vast death of the solar system, and that the whole temple of man's achievement must inevitably be buried beneath the debris of a universe in ruins - all these things, if not quite beyond dispute, are yet so nearly certain, that no philosophy that rejects them can hope to stand. Only within the scaffolding of these truths, only on the firm foundation of unyielding despair, can the soul's habitation henceforth be safely built. ... Brief and powerless is man's life, on him and all his race the slow, sure doom falls pitiless and dark.

This can lead to the expedient conclusion that we may as well eat, drink and be merry and take what advantages we can out of this material life, even to the point of exploitation of others too witless or too powerless to resist, before our time passes and we ebb away, leading to obdurate claims that religion provides the only antidote to a corrupt degenerate scientific vision, but this is not necessarily the case. One can develop an ethical view that science and the discovery of nature can provide us with an moral sensibility, because we can better know those things which we need to value most highly, such as the preservation of biological and genetic diversity, which has taken a good part of the universe's own lifetime to evolve, so that these resources will not become lost and life can continue to flourish for the future generations. Ironically, this is something that religious believers are generally no better at than expedient individuals, because belief in a creator God leads to notions of the inferiority of nature and the acceptance of ultimate destruction of the 'late planet Earth' in God's 'day of resurrection'.

In the post-Newtonian age of reductionism and artificial intelligence, some materialistic thinkers reach the conclusion that consciousness and free-will are illusions and that we are no more and no less than our functioning brain – in effect biochemical automata. Sam Harris for example, while defending a moral view of the value of nature, tries to claim free-will is an illusion:

You feel like you are a thinker of thoughts - the author of intentions - you feel like you are a subject and commensurate with that feeling is the sense that you are in a position to do what it is you do, to decide to lift my left or right hand and deliberate between the two and I can have reasons for one or the other and I'm in the driver's seat - I really am - and that's where everyone is starting. The problem with that is that objectively we know that everything you are consciously aware of - all your thoughts and your intentions and your impulses and your intentions to resist those impulses - whatever's coming up for you - but we know that's all preceded by events in your nervous system of which you're not aware and which you didn't create and the state of your brain in this moment in every sense is the product of variables that you are not responsible for - you didn't pick your parents, you didn't pick your genes, you didn't pick the environment in which your genome was going to be expressed, you didn't pick the way your interaction with other people and the world sculpted the microstructure of your brain so as to give you the brain you have - you didn't pick the number of receptors you have of every type at each synapse, you didn't pick all the charges that are currently in place in your brain at this moment - you haven't created your neuronal physiology and yet your neuronal physiology is going to give rise to every next thought and intention that shows up for you.

Francis Crick co-discoverer of DNA puts it even more pungently:

"You," your joys and your sorrows, your memories and your ambitions, your sense of personal identity and free will, are in fact no more than the behavior of a vast assembly of nerve cells and their associated molecules. Who you are is nothing but a pack of neurons - although we appear to have free will, in fact, our choices have already been predetermined for us and we cannot change that.

The trouble with these viewpoints is that the veneer of precise causality surrounding the circumstances leading to our assumed deterministic brain process only acts this way in a classical

Newtonian universe, in which each cause induces precise effects. But in the quantum universe in which we actually exist, these classical conclusions no longer have validity.

I want to convince you that both of the notions of a morally imperative religious cosmos and a physically deterministic brain with no free will are tragic fallacies and that the actual situation is both far more exciting, provocative and challenging than either of these degenerate philosophies, but that we need urgently to address our meaning and purpose to avoid these travesties of cosmological reality fatally compromising the Earth's natural fecundity and robustness and doom the vital prospects of the generations to come.

Of course, on both sides, there are also mitigating visions. The Eastern tradition includes Vedantic and Buddhist, notions in which consciousness is central to the vision quest of discovering the cosmic inner self, a path of self-discovery rather than imposed belief, which teaches that egotistical selfishness is simply a form of ignorance, that causes us endless suffering. These traditions include Tantric and Taoist ideas of the complementarity of consciousness and matter, as Shakti is to Shiva and yin is to yang, but they also suffer from inconsistencies, in which the universe is portrayed as a moral testing ground for sentient beings in a round of reincarnation of sentient beings, possibly in animal form, inconsistent with ecosystemic evolution filling all niches including predators and parasites and with the sanctity of individual species as unique and sometimes vulnerable or threatened organisms of incalculable value in their own right.

As noted, there are also 'enlightened humanists', who expound the essential goodness of natural being and of the diversity of life as the cradle and support of human existence in a world in which caring and empathy provide the connection that makes life a meaningful process, which can be made tolerable for all, if we can collectively mitigate, through compassion and informed insight, the ongoing tragedy of the commons perpetrated by people too ignorant, or selfish, to realize the essential coexistence that unites us all.

However, ultimately we come back to the crux of the problem. Is life just a meaningless rash of complexity – a planetary surface growth in a physical universe, which cares not a dot for biological or conscious survival, and in which black holes and disintegrating galaxies hold the ultimate fate of all. Or does life have some integral role in the whole cosmological process, as religions insist in all too imperative terms? But in fact a role so different from traditional ideas, that it takes the full sum of our current knowledge, from consciousness research and neuroscience through particle physics to cosmology to even begin to get a hint of an answer which can turn our understanding of the world inside out and with it our senses of time and direction and what ultimate meaning of conscious life might portend.

The Paradox of Consciousness

From birth to death, the sum total of all our experiences - all our dreams, our visions and all our observations of the physical world, and all our notions about it, come exclusively through our subjective conscious experiences. By comparison, our knowledge of the physical world comes only indirectly through our conscious experience, by cross-checking our observations with those

of others, to establish such fundamental conclusions as that we are biological organisms that will become unconscious if knocked on the head or die if we cut an artery and bleed out. In turn we become aware of the consciousness of others even more indirectly through their behavior and vivacious personae, which we closely identify with our own conscious existence, while rare instances of deeper conscious connections, such as close relatives or twins noticing when a loved one passes away or has a serious accident, remain anecdotal and ephemeral.

Effectively the world is divided between two complementary realms, the subjective realm of conscious experience and the objective realm of physical existence which we access indirectly through the former, although we recognize physical existence, and with it our biological bodies and brains, to be essential to the existence of our conscious mental states.

Subjective consciousness poses the deepest dilemma for the scientific description of reality. Although neuroscience has produced many new exciting techniques for visualizing brain function, from EEG and MEG to PET and fMRI scans, which show a deep parallel relationship between mental states and specific modalities of brain processes, these go no way in themselves to solving the so-called 'hard problem' of consciousness research – how these purely objective physiological processes give rise to the subjective affects of our conscious experiences. Philosopher Jerry Fodor famously complained:

Nobody has the slightest idea how anything material could be conscious. Nobody even knows what it would be like to have the slightest idea about how anything material could be conscious.

Little wonder then that people, since the dawn of history, have coined origin myths ornamenting their experience of the physical world with fantastic stories of spirits, deities and imaginary realms like heaven and hell, the dreamtime, underworld and afterlife, which, in the minds of believers, remain as real as the physical realm they consciously experience in waking life.

This means inevitably that addressing the question of the meaning of life has to plumb the role subjective conscious experience plays in the cosmological theatre and in the evolution of the physical universe. This brings us immediately to the question of free will.

Free-will, Determinism and Accountability

Complementing subjective consciousness is the notion of intentional will or free-will as it is sometimes, for better or worse, called. With the exception of a few catatonic individuals and extreme skeptics, all of us found our sense of our personal autonomy on our belief in our ability to make conscious decisions over our fate. Actions as simple and seemingly inevitable as getting out of bed and making a cup of coffee to start the day are all accompanied by a sense of conscious choice on which we depend and invest in in all our actions in life, predictable and unpredictable. This situation becomes particularly acute when we have to make life-changing decisions sometimes unsure of the outcomes. To deny free-will is at face value a lunacy equivalent to insisting on a catatonic or automatic reality, over which we have no conscious control.

Traditional religions hand free-will to us as a poisoned chalice. We must be allotted free-will, or we wouldn't have the ability to fall into temptation and become guilty of sin. On the other hand we are given this freedom only to have it denied, by God judging us for every transgression, so we have to obey the bondage of the moral imperative, or be damned. Worse still, we are deemed to be mortally corrupted by original sin – stemming right from the Garden of Eden, where the woman Eve was tempted by the serpent and persuaded the man Adam to eat the fruit of the knowledge of good and evil thinking it to make one wise.

In virtually all societies, the rule of law is founded on the principle that we know right from wrong and are accountable for our actions, in a tacit concession to the idea that we likewise have the free-will to err. Of course, we know from experiments running back to Pavlov's dogs that applying rewards or punishments by pain or fear can act as behavioral inducements or deterrents, without assuming free-will, and indeed deterrent punishments, from incarceration through torture to death, are designed both to punish the guilty party and to warn others of the consequences of doing likewise. Culpability for our criminal intentions and their consequential actions is conceded only if genetic, or circumstantial evidence, can be provided, or by virtue of us not being of sound mind, to mitigate our deeds.

Yet classical notions of the physical universe stemming from Newton and Laplace have led scientific reasoning towards a notion that, not only our actions, but the entire universe is causally deterministic. Laplace in "A Philosophical Essay on Probabilities" famously declared the universe to be a causal determinism:

We may regard the present state of the universe as the effect of its past and the cause of its future. An intellect which at a certain moment would know all forces that set nature in motion, and all positions of all items of which nature is composed, if this intellect were also vast enough to submit these data to analysis, it would embrace in a single formula the movements of the greatest bodies of the universe and those of the tiniest atom; for such an intellect nothing would be uncertain and the future just like the past would be present before its eyes.

The notion of the deterministic classical universe has inevitably led to the idea that free-will is an illusion and that all our actions are determined by our brain function. Consciousness came to be described as a mere epi-phenomenon, a kind of illusory internal model of reality made by the brain to focus awareness on the issues at hand, having no capacity to causally influence our physical actions or behavior, which were all a direct consequence of the firing of neurons in the brain. The growth of computer technology and artificial intelligence has added to this view of human decision-making as simply a computational process.

This approach has ramified into notions that subconscious processing in the brain may precede conscious awareness of an intention to act, leading to controversies over whether conscious will can play any part in one's intention to move even a little finger. In 1983 Benjamin Libet and co-workers asked volunteers wearing electrodes to flex a finger or wrist. When they did, the movements were preceded by a dip in the signals being recorded, which they called the 'readiness potential' - interpreted as the brain preparing for movement, which came a few tenths of a second before the volunteers said they had decided to move. Libet concluded that unconscious neural processes determine our actions before we are ever aware of making a

decision. Using contemporary brain scanning technology, researchers have since been able to predict with 60% accuracy whether subjects would press a button with their left or right hand up to 10 seconds before the subject became aware of having made that choice. This doesn't negate conscious willing because these prefrontal and parietal patterns of activation merely indicate a process is in play, which may become consciously invoked at the time of the decision, and clearly many subjects (40% of trials) were in fact making a contrary decision.

The assumption that Libet's RP is a subconscious decision has been undermined by subsequent studies. In one, subjects waited for an audio tone before deciding whether to tap a key. If Libet's interpretation were correct, the RP should be greater after the tone when a person chose to tap the key. The supposed RP was the same whether or not they elected to tap, implying the RP is simply a sign that the brain is paying attention and does not indicate that a decision has been made. Another study explains the RP as simply an indication that brain processes, which could lead to a decision, have crossed a certain threshold. Previous studies had shown that, when we have to make a decision based on sensory input, assemblies of neurons start accumulating evidence in favor of the various possible outcomes leading towards a decision when the evidence favoring one outcome becomes strong enough to cross a threshold. The team repeated Libet's experiment, but this time if, while waiting to act spontaneously, the volunteers heard a click they had to act immediately. The researchers predicted and found that the fastest response to the click would be seen in those in whom the accumulation of neural noise had neared the threshold - something that would show up in their EEG as a readiness potential. Concluding that what looks like a pre-conscious decision process may not in fact reflect a decision at all.

Other experiments suggest that in the very moments that we experience a choice, our minds are rewriting history, fooling us into thinking that this choice - that was actually completed after its consequences were subconsciously perceived - was a choice that we had made all along. In 1999, Wegner and Wheatley claimed:

The experience of intentionally willing an action is often nothing more than a post hoc causal inference that our thoughts caused some behavior. The feeling itself, however, plays no causal role in producing that behavior.

Some aspects of our conscious experience of the world do make it possible for the brain to sometimes construct a present that has never actually occurred, for example, in the flash-lag illusion, incorrectly perceiving that a flash which actually happens exactly when a rotating arrow crosses a marker, occurs after the arrow has crossed. Due to our gatherer-hunter origins, the brain is primed for very rapid visual recognition of moving targets and it does this partly by constructive prediction of the future state of a moving object. This can lead to situations where visual illusions can establish that the brain is constructing an image of the future that is incorrect. Some variants of these illusions can also show that sometimes the brain synthesizes a logic of the sequence of events after the fact and interpolates it backwards. This seems paradoxical, but other tests have confirmed that what is perceived to have occurred at a certain time can be influenced by what happens later. This again does not show that the brain is unable to anticipate reality, because it applies specifically to very short time interval spatial reconstructions by the brain, which would normally be more accurate by retrospective interpolation, aiding survival, and thus being selected for.

Regardless of cultural and religious history, belief in free-will appears to be a normal biological condition. In 1998, the International Social Survey Programme asked 40,000 people from 34 countries: "Do we make our own fate?" More than 70 per cent answered in the affirmative. In experiments where volunteers read statements reinforcing or undermining belief in free will, the first group behaved no differently from volunteers who had not been primed to think of free will at all, indicating we naturally act as though we possess it. Moreover those with a greater belief in their own free will were generally rated as performing better than those with weaker beliefs, suggesting belief in free will is effective in our actions. And ironically people don't just believe they have free will, they also believe they have more of it than others.

We will thus reject the notion that free-will is an illusion and that consciousness plays no role in decision-making and present a radically different perspective, based on quantum reality.

Quantum Reality and the Conscious Observer

Two founding discoveries of physics since the nineteenth century have transformed our notion of the classical universe. Special relativity has shown us that space and time and energy and momentum are coupled in such a way as to both define the speed of light as the upper limit for causal propagation, and bringing with it the notion of both retarded and advanced solutions to the fundamental equations of motion – with retarded solutions travelling in the usual direction to later times and advanced solutions being time-reversed.

At the same time, quantum physics has shown us that it is impossible to deterministically specify the state of any fundamental wave-particle, such as an electron, or photon, because energy is equivalent to frequency and momentum equivalent to wavelength, and we can't determine the frequency of a wave at an instant because we need a certain amount of time over several wave beats to make a measurement of a given accuracy, since we have no finer measure than the quantum itself. Effectively the universe has thrown in a cubic centimeter of chance into the equations – a volume of momentum times distance, or energy times time, within which arbitrarily wild fluctuations can and do occur.

Each quantum manifests discretely as a particle and continuously as a wave. While we can be relatively certain about average behaviors of many wave-particles, for example the photons of light making the interference rainbows we see on a CD or DVD, we can't know where any individual photon will end up. The CD rainbow is an example of a many-slit interference experiment, generated by reflections between the slits forming the data tracks. In the usual experiment, a photon is discretely released as a particle from an excited atom in a light source making a discrete orbital transition to the ground state. It travels as a wave through space, passing through two slits in a barrier as a wave, and traveling on to a photographic plate where it is absorbed discretely by an atom on the plate. Over time, the pattern of these absorptions shows up as bands of dark and light confirming the wave nature of the light emerging from the two slits, and that the photon passed through both the slits at once to make the interference bands. But we have no idea where each individual particle will be absorbed, because all we know from

quantum mechanics is that the probability of them being in any particular place varies with the intensity of the wave – the amplitude squared. So a single photon could end up almost anywhere.

Quantum mechanics predicts an overlapping set of probabilities superimposing all the possible states. However when a conscious observer makes a measurement, the superposition of all the possible states in the wave appears to collapse into one unpredictable outcome – the particle is absorbed by a single atom somewhere the amplitude is non-zero in the wave function spreading across space-time. It is as if each photon itself has a form of free will, as long as they conform on average to the wave function intensity. This problem was made famous in Erwin Schrödinger's cat paradox experiment. A cat is subjected to Russian roulette in a closed box driven by a radioactive source with a probability of a half of going off during the experiment, killing the cat. Quantum physics says the cat is both alive and dead with equal probabilities, but when we open the box we find it is either alive or dead and history has been made.

John von Neumann the mathematical physicist who also invented the computer CPU suggested that quantum observation is the action of a conscious mind and that everything in the universe that is subject to the laws of quantum physics creates one vast quantum superposition. But the conscious mind is different, being able to select out one of the quantum possibilities on offer, making it real to that mind. Max Planck, the founder of quantum theory, said in 1931, "I regard consciousness as fundamental. I regard matter as derivative from consciousness." Werner Heisenberg also maintained that wave function collapse - the destruction of quantum superposition - occurs when the result of a measurement is registered in the mind of an observer.

Uncertainty is not just a hypothetical idea about measurement either. The vacuum is teeming with virtual particles of every possible type appearing out of nowhere and disappearing again within the cubic centimeter of chance uncertainty dictates. These virtual particles are also responsible for the forces of nature, such as electromagnetism, which is due to the exchange of virtual photons between charged particles such as electrons. When we apply energy to electromagnetic circuits, for example in a radio antenna, the photons generated making the music on our airwaves are literally virtual photons that have been drawn out of thin air by the oscillating electromagnetic fields picking up virtual photons and making them real by giving them positive energy. Quantum electrodynamics, devised by Richard Feynman, has proved to be the most accurate theory of physics ever, predicting the magnetic moment of the electron due to emitting and re-absorbing virtual photons, agreeing with the experimental result to an accuracy of one part in 10^{10} . Couched in terms of special relativity, all such quantum field theories likewise admit both retarded and advanced solutions.

This picture of quantum uncertainty has been further deepened by the notion of quantum entanglement. This is the spooky 'action at a distance' that Einstein decried: "I don't believe that God is playing dice with the universe". But later this spooky connection became an experimental reality. If we generate two particles in the same wave function, it turns out that sampling one immediately tells us about the complementary one, without limits on their exchanging information at the speed of light. For example an excited atom of calcium needs to radiate two photons together because the excited and ground states are both spin zero, but a photon carries a spin of one, so emitting two complementary ones will cancel the spins out. The atom thus radiates two photons in opposite directions with complementary polarization. Measure

the polarization of one along a given axis and you know the other instantaneously in a way that is not bounded by the limits of speed of light communication between the two detectors, since the effect persists even when we change the detector's orientations over time intervals too short for light speed communication to occur between them. Entanglement and related phenomena such as quantum discord show that uncertainty also plays a significant role in the way physical and biological processes occur.

Quantum discord is an extension of entanglement to more general forms of coherence, in which partial correlations induced through interaction with mixed state particles can still be used to induce quantum correlated effects. Quantum discord is a promising candidate for a complete description of all quantum correlations. Coherent interactions can harness discord to complete a task that is otherwise impossible. This advantage can be directly observed, even in the absence of entanglement. Quantum discord does not require isolation from decoherence caused by entangled particles getting knocked out of synch by a third party quantum, and can even derive additional quantum information from interaction with mixed states which would annihilate entangled states. Quantum discord is thus a viable model for processes ongoing at biological temperatures, which could disrupt full entanglement.

Uncertainty and entanglement also raise deep questions about the nature of causality in time. A photon can be absorbed anywhere inside its spreading wave function, but this spreads both in space and time. When light is passing through a semi-transparent medium, it could be absorbed sooner or later, but somehow the universe never makes a mistake resulting in two absorptions, even when a particle is absorbed long after the wave front has passed other locations.

Quantum reality thus has a form of hand-shaking between past and future, which we can see more clearly in the Wheeler delayed choice experiment. Supposing we look out at a very distant galaxy whose light was emitted shortly after the universe began, which is gravitationally lensed by a nearer one so, we can see two split images, as in the double slit experiment because the light has followed two paths around both sides of the intervening galaxy. If we bring these two together in a detector, we will get an interference pattern confirming the photon went around both sides of the intervening galaxy on its way here, but if instead we put separate photon detectors pointing at each image, we will find it went only around one side of the galaxy. In this case the interference fringes disappear just as they do in the double slit apparatus if we try to detect which slit the photon went through, but here we are making the choice long after the photon traversed the universe. It is thus clear that, within the wave function, there is a hand-shaking between past and future, in which future absorbing states act as boundary conditions on the collapse of the wave-function to the particle, as definitively as the past emitting state(s). This is also true of entangled states and means that the physics inside entanglement in a fundamental sense anticipates future absorbing states.

This doesn't mean that entanglement or uncertainty can be used to deterministically predict the future, because entanglement can't be used to send a causal message faster than the speed of light. It is just the correlation between internal states that is instantaneous and has to be to avoid particles appearing out of nowhere more than uncertainty allows.

A central error made by people criticizing free-will is that the quantum universe is divided between deterministic laws, including both Newtonian mechanics and the Hamiltonian wave functions of quantum mechanics, the only exception being the probability laws of quantum mechanics giving rise to particle ensembles, thermodynamics and kinetic processes. These are, in turn, claimed to be as unyielding to free-will as determinism, because we are merely replacing stipulated actions by law with random unspecified actions. Since the universe is governed by unyielding determinism and unrelenting randomness, the notion of free-will is meaningless, even in the quantum universe. This then enables the argument to descend to a reductionism, in which particulate molecules interact kinetically, reducing the brain to a complex probabilistic automaton.

Carlo Rovelli, a gravitational theorist, makes exactly these mistakes claiming that:

Free will has nothing to do with quantum mechanics. We are deeply unpredictable beings, like most macroscopic systems. There is no incompatibility between free will and microscopic determinism. ... The issue has no bearing on questions of a moral or legal nature. Our idea of being free is correct, but it is just a way to say that we are ignorant on why we make choices. The first is that the indeterminism of quantum mechanics is governed by a rigorous probabilistic dynamics. The equations of quantum mechanics do not determine what will happen, but determine strictly the probability of what will happen. In other words, they certify that the violation of determinism is strictly random. This goes in exactly the opposite direction from human freedom to choose. If an element of randomness is sufficient to account for free will, there is no need to search it into quantum uncertainty, because in a complex open system such as a human being there are already many sources of uncertainty, entirely independent of quantum mechanics. The microscopic atomic dynamic inside of a man is influenced by countless random events: just consider the fact that it occurs at room temperature, where the thermal motion of the molecules is completely random. The same balance between rigidity and chance plays an important role in our brain, which functions, in spite of the illuminating similarities with good software, because of the ubiquity of statistics in his working. ... Our brain is a machine, but it is a machine that works in a manner where statistical elements play a continuous and persistent role, next to deterministic functions.

The problem with this approach is that we can exert the strictness of the probability interpretation only when a process is repeated in a systematically consistent way, as in an interference experiment to form a statistical particle distribution. If we allow only one event to occur in a given context, such as letting one photon through the apparatus, we simply don't know where it will end up. But all human decision-making is of this second type - that is it is not repeated - history is made and a new situation results. Evolution through mutation shares this precisely at the quantum level, which never fully converges to the probability interpretation since many mutations are adventitious and then become fixed by selection. The brain shows rich avenues for quantum fluctuations of this kind to become amplified into global activation of new states and then fixed by synaptic changes involved in long-term potentiation have been found to lead to epigenetic changes.

Peter Tse has an interesting answer:

If the brain sets up criteria for future firing, and if spike timing is made random by the amplification of quantum-level events in the synapse, it is down to chance how these criteria are met. The inputs that meet criteria cannot be predicted - the outcome depends on which spikes coincidentally arrive first. ... The missing piece is that neurons can rewire each other. Spikes don't just trigger subsequent spikes in other neurons. Within milliseconds, they can temporarily change the degree to which synapses -- the nerve structures that pass signals to other neurons -- trigger future spikes ... rapid bursts of spikes trigger the opening of specialised synaptic receptors, altering the responsiveness of neurons to subsequent spikes. ... With synaptic reweighting, mental events don't change their present physical basis. They change the neuronal basis of possible future events. But this alone is not enough for free will. The brain of a zombie who lacked consciousness could use this mechanism too, but we would not say it had free will. To have free will requires that our self - that which we feel directs our attention around our conscious experience - has some say in the matter of what we do or think. If consciousness plays no part in the synaptic reweighting process, there is hardly a free will worth having. Fortunately, the neural activity associated with consciousness does play a necessary role.

He illustrates this with the brain deliberating an outcome in a novel situation, which has features that have not occurred previously, leading to a new response as a result of the unstable brain dynamics, which then becomes a process in the real world realizing the outcome. We could in principle then make verifiable tests that consciously willed actions do indeed result in historically verifiable outcomes, closing the circle.

When we involve quantum entanglement and its generalized forms such as discord, the stakes become more interesting because we have no model of how the universe actually correlates such processes. Hidden variable theories have been proposed. David Bohm's pilot wave theory, for example, models quantum processes in terms of particles having a real location modified by a quantum potential which acts at a distance in such a way as to generate the same outcomes as those predicted by quantum mechanics.

Strong measurements that disturb the quantum state cannot be used to investigate an ongoing wave function because they will cause wave function collapse. For example, testing whether a particle has passed through one slit of a two slit apparatus destroys the coherent interference fringes, but weak quantum measurement which only marginally perturbs the wave function, e.g. by a small change in polarization, can be used to build up a statistical profile of how a particle traverses its wave function.

Weak quantum measurement can be performed in a double slit apparatus generating single photons using a laser stimulated quantum dot and split fiber optics and it shows us what the trajectories look like inside the wave function. The overlapping wave function is elliptically polarized in the xy-plane transverse to the z-direction of travel. A calcite crystal is used to make a small shift in the phase of one component, while the other retains the information, subsequently leading to absorption of the photon on a charged coupled device. By combining the information from the two transverse components at varying lens settings, it becomes possible to make a statistical portrait of the evolving particle trajectories within the wave function. Pivotaly, the weak quantum measurement is made in a way, which is confirmed only in the future of the ensemble when the post-selection absorption takes place.

When we examine the result, the internal trajectories look consistent with the Bohmian interpretation. Thus, rather than a universe with temporal determinism, with causes strictly preceding effects, interrupted by purely random uncertainty variables, we may be actually living in a universe with a hidden variable interaction with hand-shaking boundary conditions imposed symmetrically by both past and future states..

Weak measurement also suggests that, in some sense, the future is determining the present, but in a way we can discover conclusively only by many repeats. Focus on any single instance and you are left with an effect with no apparent cause, which one has to put it down to a random experimental error. This has led some physicists to suggest that free-will exists only in the freedom to choose not to make the post-selection(s) revealing the future's pull on the present. Yakir Aharonov, the co-discoverer of weak quantum measurement sees this occurring through an advanced wave travelling backwards in time from the future absorbing states to the time of weak measurement. What God gains by 'playing dice with the universe', in Einstein's words, in the quantum fuzziness of uncertainty, is just what is needed, so that the future can exert an effect on the present, without ever being caught in the act of doing it in any particular instance, neatly explaining why no subjective account of prescience can do so either. Post-selection can also induce forms of entanglement in particles even if they have no previous quantum connection coupling their wave functions.

The link with Bohm's pilot wave theory became reinforced when a critical experiment demonstrated the existence of so-called "surreal Bohmian trajectories" which could violate the predictions of quantum theory. The experiment first prepares a pair of highly entangled photons with complementary polarization and then passes one into a double slit apparatus in which the photon to be measured is directed to one or other slit depending on its entangled twin's polarization. The measured photons are then passed through an apparatus to do weak quantum measurement of their trajectories as an ensemble and then detect the eventual position destructively. However when weak measurement is used to detect the trajectory close to the slit. it confirms that the photon has gone through the correct slit according to its assumed polarization as subsequently measured by sampling its entangled twin. However, as the position of weak measurement moves towards the photographic plate the predictions fall to an even superposition of the two polarizations. Since the weak quantum measurement is a physical realization of the ensemble trajectories going to this particular point on the plate, the surreal trajectories are real but the prediction made of the spin by the entangled twin has become changed. This implies in turn that changes have occurred between entering the slits and hitting the plate of a non-local nature, implying the there is substance to the Bohmian reality.

Quantum uncertainty in brain processes could thus provide a loophole both for free will and for conscious anticipation, if decision-making corresponds to unstable processes where quantum uncertainty means we can't predict the outcome of the brain state. This brings us to the question of the role chaos may play in generating unpredictability.

A Perfect Storm at the Edge of Chaos

A third discovery in physics much closer to home paradoxically took much longer to become recognized. The classical paradigm of the rule of order meant that physicists thought all real phenomena would have to be structurally stable and not disintegrate under arbitrarily small perturbation, until Lorenz studying turbulent weather in the 1960s came up with a system of equations which demonstrated the ‘butterfly catastrophe’ – that for some ‘chaotic’ systems, arbitrarily small perturbations can grow exponentially, so that the disturbance of a butterfly’s wings in Hawaii can later grow into a tropical cyclone hitting Mexico. Chaos also has two other key properties – it thoroughly mixes dynamical space topologically and it is permeated with a dense set of repelling orbits, while ordered systems converge toward a stable set of attracting orbits.

Earlier Werner Heisenberg had prophetically commented: "When I meet God, I'm going to ask him two questions, 'Why relativity?' and 'Why turbulence?' I really believe he will have an answer to the first" - implying the second, i.e. chaos is the very nemesis.

Suddenly people realized that chaotic instability underlay a whole raft of phenomena, from fluctuations in the populations of rabbits through to the forms of snowflake-like fractal sets in dynamical systems. Evolution and climax ecologies both operate at the so-called ‘edge of chaos’. Complex biological systems are particularly prone to dynamics which include transitions in or out of chaotic phases, and these include the very phenomena in the brain we associate with conscious decision-making, where all the competing factors relating to an uncertain decision we are about to make, lead to an unstable tipping point.

Chaos is essential to such processes, because it provides a form of ‘annealing’. Ordered dynamical systems tend to be totalitarian, getting stuck by drawing every state into one of their stable attractors, making it very difficult to avoid a ‘fait accompli’. Chaos enhances a system’s dynamical unpredictability, so it can end up almost anywhere, avoiding it getting stuck and enabling it to form or enter a new attractor as we make a transition from chaos to order.

Quantum systems engaged in chaotic dynamical processes can also enter paradoxical states of entanglement. Many closed quantum systems display repression of classical chaos. For example a confined wave function under chaotic energisation, such as the quantum stadium, displays scarring of the wave function, causing the probability to cluster around the repelling periodic orbits. However this is not true for open or interactive systems. An indication of how the transition from classical to quantum chaos might lead to complex forms of quantum entanglement can be gleaned from an ingenious experiment forming a quantum analogue of the kicked top using an ultra-cold cesium atom kicked by both a laser pulse and a magnetic field. In the experiment the lack of a dip in linear entropies in the chaotic regime indicates entanglement with nuclear spin, showing quantum chaos can lead to new forms of quantum entanglement.

Studies of brain waves in the electroencephalogram show that these are broad-spectrum excitations associated with chaotic processes, rather than the narrow peaks we associate with ordered resonances. Work by Walter Freeman in the 1990s showed that processes such as sensory recognition and learning can be explained by dynamical evolution of chaotic strange

attractors through transitions in and out of chaos, in which a high-energy chaotic phase frees up the dynamic to explore the phase space of possibilities, while a lower-energy transition back towards order seals a perception or decision into place. Attractor based dynamics can also explain how learning occurs if a new situation arises by forming a new attractor by bifurcation out of chaos.

Moreover the brain consists of a fractal-like system of interconnected neuronal assemblies, where in cases where there are potential tipping points, instability in a single neuron can lead to cascades of instability in larger neural assemblies, leading ultimately to a change in the whole brain state, as has again been demonstrated by experiment. Between the global, cellular and molecular levels are a fractal cascade of central nervous processes, which, in combination, make it possible for a quantum fluctuation to become amplified into a change of global brain state. The neuron is itself a fractal with multiply branching dendrites and axonal terminals, which are essential to provide the many-to-many synaptic connections between neurons, which make adaptation and the representation of reality possible. In all tissues, biological organization is achieved through non-linear interactions which begin at the molecular level and have secondary perturbations upward in a series of fractal scale transformations through complex molecules such as enzymes, supra-molecular complexes such as ion channels and the membrane, organelles such as synaptic junctions, to neurons and then to neuronal complexes such as cortical mini-columns and finally to global brain processes.

Because neurons tend to tune to their threshold with a sigmoidal activation function, which has maximum limiting slope at threshold, they are capable of becoming critically poised at their activation threshold. It is thus possible in principle for a single ion channel, potentially triggered by only one or two neurotransmitter molecules, if suitably situated on the receptor neuron, e.g. at the cell body, where an action potential begins, to act as the trigger for activation.

The lessons of the butterfly effect and evidence for transitions from chaos in perceptual recognition suggest that if a brain state is critically poised, the system may become sensitive to instability at the neuronal, synaptic, ion-channel, or quantum level. A variety of lines of evidence have demonstrated that fluctuations of activity in single cells can lead to a change of brain state when the global brain state is critically poised for example under stochastic resonance, in which the presence of chaotic excitation or noise, somewhat paradoxically, leads to the capacity of ion channels to sensitively excite hippocampal cells and in turn to cause a change in global brain state. Specific neuronal circuitry also facilitates such processes. Chandelier cell activation can result in poly-synaptic activation of pyramidal neurons that drive active output to other cortical regions and to the peripheral nervous system, in such a way that single action potentials are sufficient to recruit neuronal assemblies that are proposed to participate in cognitive processes.

Confirmation of edge of chaos processing has come with several recent experimental studies. Consciously perceived stimuli appear as islands of relative stability in a chaotic sea of unconscious processing. High density EEG experiments confirm that the brain, is self-regulated at the boundary between stable and unstable regimes, a form of self-organized criticality, allowing it to maintain high susceptibility and sensitivity to stimuli. During loss of consciousness due to anesthetics, the number of resonance modes at the edge of instability decreases,

independently of the type of anesthetic and specific features of brain activity, but drifts back toward the boundary during recovery of consciousness. These findings imply that dynamics at the edge of instability are essential for maintaining consciousness.

Enter the Holographic Brain

However, there is another aspect of brain activity that is also critical for our understanding, which comes very close to the idea of quantum measurement. A central way the brain distinguishes signal from noise is whether excitations are “in synch” with one another – i.e. they rise and fall in time with one another coherently. Circuits which do this tend to be reinforced and couple together to make a larger scale dynamical system. This attribute is termed ‘phase coherence’ because the phases of the two waves – i.e. the angle between rise and fall, flow together.

Karl Pribram coined the term ‘holographic brain’ for this dependence on phase-front processing, because it is similar to the way a holographic photograph stores 3-D wave information on a photographic plate using coherent laser light, where all the photons are caught ‘in synch’ in the same wave function.

One can thus picture brain processes as arising locally and those which achieve phase coherence coupling together and competing with others out of synch, with global attention processes scanning for dominant coherences that subsequently rise to conscious attention. This process is a very close analogy to quantum measurement where wave beats are a direct discrete measure of phase coherence.

Of course there are many people who will then object that the firing of even individual neurons happens on a far grosser scale than individual quanta at the molecular level and the uncertainty can play no significant role in conscious decision-making. This is again incorrect, because neurons can self-tune to their activation threshold with sigmoidal acute activation triggers so that changes at an individual neurotransmitter receptor or even a single ion channel at a critically poised neuron can result in activation, leading in turn to an escalating cascade of activated neural assemblies.

Moreover many sensory processes are known to be sensitive down to the one quantum level. Recently experiments have verified, for example, that it is possible for the human eye in the limit of sensitivity, to detect a single photon. Membranes of cochlear cells oscillate by only about one H atom radius at the threshold of hearing, well below the scale of individual thermodynamic fluctuations and vastly below the bilayer membrane thickness. Moth pheromones are similarly effective at concentrations consistent with one molecule being active, as are the olfactory sensitivities of some mammals.

Furthermore, although long distance transmission of signals is driven by the discrete pulse-modulated action potentials of pyramidal neurons, many neurons at the organizing centre of neural assemblies have graded potentials with continuous variation, so the organizing process cannot be reduced to a digital process like that of a silicon-based digital computer.

The nature of wave-front processing raises a question about whether brain excitations might be more than an analogy with quantum processes and actually be in some sense inflated quantum excitations. In such a situation, coherence between excitations would be equivalent to quantum entanglement and raise intriguing questions about the causality of brain processes. We would move beyond merely citing quantum uncertainty as a loophole in determinism and enter unknown territory about the space-time properties of entangled brain processes.

Biology has been discovered to contain a challenging diversity of quantum phenomena. Enzymes commonly use quantum tunneling as a means to traverse the activation barrier. When a photosynthetic active centre absorbs a photon in a plant, the wave function of the excitation is able to perform a quantum computation by superposition, which enables the excitation to travel down the most efficient route through the molecular web to reach the chemical reaction site. Quantum entanglement is believed to be behind the way some birds navigate in the magnetic field. Light excites two electrons on a molecule and shunts one of them onto a second molecule. Their spins are linked through quantum entanglement. Before they relax into a decoherent state, the Earth's magnetic field can alter the relative alignment of the electrons' spins, which in turn alters the chemical properties of the molecules involved. Quantum coherence imaging is an established technique in tissue imaging, demonstrating quantum entanglement in biological tissues at the molecular level. Interesting candidates for entanglement in the brain could occur as a result of spin are Calcium phosphate Posner's clusters, which have an estimated the coherence time of over a minute.

If the brain is able to generate entangled excitations the lifetime of these excitations could create a potentially anticipatory loophole on a similar time scale to the conscious moment of hundreds of milliseconds which might provide exactly the anticipatory advantage that resulted in the evolution of consciousness nervous systems to avoid potentially lethal predator attacks.

To put this in a molecular context and to see the whole picture, we now need to throw the covers off the cosmological universe and where life fits into the picture.

Origin Myths and Apocalyptic Allegories

Let's turn back for a minute to traditional ideas of how the universe began. Cultures since the dawn of history have devised creation myths to explain how we find ourselves in the world. The San Bushmen, one of our most ancient founding cultures that go back 150,000 years to the mitochondrial Eve, tell a story of a creator deity making in turn a second god of misfortune and chaos and female partners for them both, who in his earthly existence was a supernatural trickster capable of assuming any form, who changed people into animals and brought the dead back to life. He created the earth with holes in it where water could collect and water and rain, the sky, the sun, moon, stars and wind, and all the plants and animals and gave them names. Then he put life into humans and gave to them all their weapons and implements and the knowledge of how to exist in the wild. And he ordained that when they died they should become spirits, who would live in the sky with him and serve him. The Bushmen do not worship their deities in fear or supplication, in the way the major social religions do, but rather see them as quizzical elements

far off in their own domain, who manifest indirectly through natural phenomena and the vagaries of fate.

Although charmingly evocative, the sabbatical creation sequence of Genesis one defies the natural order in a way that makes no cosmological or biological sense. The universe is a logos - enunciated verbally - 'Let there be light and there was light'. Light, immediately adopting the forms of day and night, is created before the Sun, Moon and stars. The photosynthetic plants are also impossibly created before the Sun. The firmament of the heavens is "raqiya" a beaten hemispherical bowl, dividing waters above and below, in which the stars are fixed as adornments and the Sun and Moon are mere lamps to light the day and night. Earth is a flat domain created by bunching the waters under heaven to one place. The fishes and whales and the birds are created a day before the land animals and long after the plants. The Sabbatical deity is 'Elohim - God in the plural - with implications of being a deity partnership in consort, culminating in humans being made female and male in their likeness. This is echoed in the proverbs where Wisdom portrayed as a female who says "I was with him from everlasting before the Earth was." To try to use this charming allegory to deny the evolution of natural life in the name of religious belief is a frank disgrace of bibliolatry the written word version of idolatry.

The Eden tale stands in stark contrast. A lone and lonely God sets up a tender trap in paradise with the Tree of Life and the Tree of Knowledge of Good and Evil. The woman Eve, conceived out of Adam's rib, is tricked into eating the fruit of knowledge, leading to woman being cursed as the 'devil's gateway' to suffer the pains of childbirth and be ruled over by her husband, giving patriarchy free reign, and both woman and man doomed to mortality to live struggling with the thorns and thistles, exiled from the Garden by a flaming sword.

With the development of urban culture, deities became totems for city-states and empires vying for dominance. The nature of God underwent a change, to become a moral deity cursing the people for infidelity or selfishness to enhance the internal cohesion of the state. The rise of patriarchal dominance at the same time resulted in God becoming connected with the control of female reproduction. Recent genetic evidence comparing Y-chromosome and mitochondrial evolution has shown that, with the advent of the agricultural era, the reproductive sex ratio went from about a fairly natural ratio of 2 women to each reproducing man since all women can get pregnant but only some men have partners, to 17 to 1, due to powerful landlords in agrarian societies controlling female reproductive choice for themselves in harems and sexual slavery.

Yahweh became the abstract totem deity of the bride Israel, in the same way that other deities, from old El of Canaan, to Marduk of Babylon were totem deities. As successive societies rose and fell, so the cosmology evolved by cross-fertilization. Originally in Hebrew religion there was no place for heaven, or hell, just Sheol, a primitive underworld of the dead. It was only with the influence of Zoroaster that the idea of apocalyptic renovation in a future day of judgment arose and became incorporated into the thought of exilic Jews in Babylon, who were then allowed to return to Israel by Cyrus the Mede, 'anointed by God' as a Jewish messiah.

In modern Judeo-Christian thought, we end up with a syncretic false perspective, in which the universe has become a cosmic moral passion play in which we are condemned to torture or given eternal life in a sexless heaven with angelic wings which makes no physical sense in the rarified

upper atmosphere or outer space and which has no meaningful future creative or enlightening purpose, frozen forever in eternal time.

As we have learned from sociobiology, morality is not an imposed fundamental of the cosmological design, but a natural evolutionary feature of animal and human societies, in which intra-social strife is repressed to enhance inter-social domination. In the Judeo-Christian cosmology we are left with a vestigial creation myth in Genesis 1, inflated by the believing mind into claims that the Earth is only 4000 years old, and that, without any shred of corroborating evidence, or even a plausible description in the scripture of how this might have come about, that the woolly-haired God has created the universe and all life within it by breathing on it, or naming it in the same way the San Bushmen imagined it was done.

The Quranic account, while couched in Arabic poetry, is even more insubstantial, revolving around a simplified Eden story, leading to fantastic tales of a sexual heaven where female hours are made anew as virgins every day for the pleasure of men, and the day of judgment is accompanied by eclipses and the Moon being torn in two, the one commonplace and the other a cataclysm impossible except in the birth of the solar system.

When we turn to the teachings of the Upanishads and Buddhism, we find a more subtle cosmology that has become centered around the conscious quest for enlightenment. The entire perspective is that of the sentient conscious mind seeking the cosmic self within. We have Vishnu the sustainer dreaming the universe in the form of Brahman manifesting the phenomena of existence, as a lotus out of Vishnu's navel. In other accounts we have Shiva as the conscious avatar in sexual embrace with Shakti-Kali as material and temporal reality and in their retreat from cosmic union, thus manifesting all the phenomena of temporal existence, astutely portraying the existential condition as an intimate sexual union of subjective mind and material body whose truth has become lost in the myriad reflections of sentient beings engaging the material world. The intrinsic value in these accounts lies in their being recognized as allegories, just as the sabbatical creation is a beautiful allegory, but a fraudulent danger to our survival when fraudulently claimed to be an actual cosmology.

The Buddhist account is a story of releasing sentient beings from the grasping bondage and torments of the ego, in a philosophy of undivided phenomena, all of which are undivided because they are integrated states of mind, leaving the objective physical world as part of Maya, the domain of illusion. The end result is a cosmology of conscious cycles of incarnation in which only the sentient being exists and has validity and all the diversity of nature, from simple organisms to humanity, are caught in a moral cosmology which is in fundamental conflict with nature, because it fails to recognize the difference between an endangered bird, and a feral rodent which eats it, as both are simply sentient beings. It is another moral cosmos, in which the wheel of life, containing realms, from hell, through hungry ghosts to titans, are archetypal reflections of differing states of mind. It is thus again not a valid cosmology, but a psychological theory of mind, claiming to address the existential dilemma, without offering a realizable description of nature or the physical world.

None of these accounts contain a remotely plausible or verifiable cosmology of the universe, nor do they make any meaningful explanation of the origin or purpose of conscious life in the

cosmological process. The struggle to understand the natural universe as it is, was not achieved easily. People like Galileo, who challenged the Earth-centric view, were threatened with excommunication, and attempts have been mounted ever since to insist, regardless of the lack of evidence, that God created the universe either by command or by artifice in the manner we create artifacts and machines, and to deny the natural emergence and evolution of life.

Coming to Terms with the Cosmological Universe

The universe has proved to be vastly older, huger, more populous, varied and far more deeply confounding than any of the ideas of traditional belief systems. Natural reality is inscrutable and existentially challenging and although we have a fairly clear idea of the general picture, the exact description of life, the universe and everything isn't completely signed and sealed. However this is a much more healthy situation than a religious cosmology that resists the evidence and seeks a dominant regime of order through preconceived beliefs. It's a sign of our growing maturity to accept uncertainty in the cosmic description.

In our own galaxy alone there are a hundred billion stars, a good proportion of which are now known to have planetary systems. But there are also a hundred billion galaxies, stretching out to the limits of the observable horizon where we are effectively seeing back to the cosmic origin, because their light has taken over ten billion years to reach us. We also know the universe had an 'explosive' origin around this time, around 13 billion years ago, because there is a universal cosmic background radiation at around four degrees absolute, which corresponds to the hot blast, later cooled almost to zero by the expansion of the universe, just at the point that the hot opaque charged plasma condensed into neutral atoms, allowing the universe to become transparent and the photons to escape.

But the 'big bang' was no ordinary explosion. It seems to have occurred from a state of high symmetry immediately followed by a phase of exponential expansion in around 10^{-12} seconds, which goes by the name of cosmic inflation. Like many other aspects of the universe, life and consciousness, inflation is still in the process of confirmation, but it ties together with some other issues about how the forces of nature linking matter and radiation that govern everything from how stars and galaxies form to molecular life and evolution came about. Nor is the 'big bang' a candidate for God's creation of the universe, because according to relativity, space and time would come together as the lines of longitude do at the south pole, so we don't necessarily have any meaning of time 'outside' or time 'before' the origin, although in some models, inflation is like a fractal, leaving behind universes like ours, and in others the big bang may have resulted from a bounce out of a big crunch. The ideas here are as wild and varied as the uncertainties.

Nevertheless there are four well-known forces governing the evolution of the universe, electromagnetism making light, electromagnetic phenomena and driving molecular chemistry; the weak force governing the radioactivity that exchanges neutrons and protons; the strong (colour) force governing the high energy attractions that hold the nucleus together, causing nuclear fission and the fusion driving stars, and gravity. These are now very different, but they appear to converge at very high energies and the idea is that, just after the big bang, they were a single super-force and that inflation occurred because the universe had a universal anti-gravity

caused by the fact that, although very hot, the universe was a little below the unification temperature, causing a negative mass-energy. Almost as soon as it began and made the universe huge, the symmetrical state froze out like a ferromagnet, where the polarized magnetic state is lower energy than the symmetrical state, giving us the twisted form of the forces we see today where the weak force is chiral, the strong force goes in three colours of quark and there is an excess of matter over anti-matter, with atoms and molecules having exclusively positively charge nuclei and negative charged orbital electrons. Inflation also explains why the total kinetic energy of the universe flying apart is almost exactly equal to its gravitational potential energy, leaving us unsure whether it will expand forever or collapse back again.

Each of the quantum forces is mediated by radiation particles called bosons, for example the photons that are exchanged between charged particles such as the electron, which along with the positively charged proton and neutron constitute molecular matter. These matter-forming particles are called fermions and can only group in pairs, causing matter to become incompressible, while bosons can clone any number together, as in a laser.

But this isn't the whole story, because there are two dark clouds hanging over cosmology. The first is dark matter. When we look at a galaxy, there simply isn't enough mass in the stars and black holes formed by large stars which have gobbled up other matter, exploded and collapsed under their massive gravity to hold a spinning galaxy together. Nearly all the mass must be hidden in some other massive form of 'dark matter'. At the same time, careful measurements show the universe is not just expanding, but the expansion is accelerating, so there is another entity 'dark energy' causing the acceleration. No one yet has a clear answer to what either of these actually are, although there are many competing theories.

Also we don't have a unified 'theory of everything' that can fully unite gravity with the other three forces of nature. There are several candidates extending the standard model which unifies the other three, but none of the ideas such as super-symmetry between bosons and fermions, or its extension to superstrings, where particles become loop vibrations, has achieved confirmation so far in experiments such as the LHC.

(Continued on Part II)