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CTOE: THE COMPLETE THEORY OF EVERYTHING

The goal of this Complete Theory of Everything (CTOE) is the most accurate and maximally explanatory unified model of all major aspects of reality possible. It must be as consistent with modern science as possible without convincing reasons to the contrary, and it, in itself, must present a convincing, and logically consistent and logically complete internal structure. I have high confidence that in the main the theory achieves this goal, though of course reality itself is always the final arbiter. And, of course, to the extent the theory is correct it's a discovery, rather than a creation.

In achieving this goal, the theory reveals a number of new fundamental principles, explores their implications on current science, and provides solutions to many previously intractable scientific and philosophical problems.

1. It provides a clear explanation of the nature of existence.
2. Convincingly demonstrates the universe consists of information and is computational.
3. Shows how the computational universe computes a universe that is simultaneously quantum and relativistic.
4. Thereby opens a path to the unification of relativity and quantum theory.
5. Resolves the apparently paradoxical nature of the quantum world.
6. Clearly defines and proves the existence of a common universal present moment.
7. Solves the problem of how nonphysical laws of nature control a seemingly physical world.
8. Provides a clear and obvious explanation of consciousness and the 'hard-problem'.
9. Explains how the world of our experience is a virtual reality, or simulation, constructed by our own minds.
10. Opens a path to realization, defined as experiencing reality as it actually is, in transcending the illusions of our mind's simulation of reality.

I: FUNDAMENTALS

SIMPLE INTRODUCTORY SUMMARY

This introductory summary presents the fundamental core of the theory. A more complete presentation with supporting evidence is presented in the following chapters. More advanced technical discussions and proofs appear in the 'Optional' chapters, and may be skipped without losing the essence of the theory.

1. The universe consists entirely of a substrate of existence, and the forms of existence that occur within it. The fundamental substrate of existence is called the quantum vacuum.
2. All the forms of existence are forms of information, the most basic of which are the information of the elementary particles and particle properties. Everything else in the universe are emergent aggregates of these elemental information forms. Everything, including ourselves, is the complete exact information of what it is made real and actual by occurring within the underlying medium of existence.
3. The universe is a computer, that continually computes its evolution from the complete information of its previous state.
4. It does this on the basis of virtual information of the laws of nature in the complete fine-tuning, which is all the information necessary for its computations.
5. The apparent 'physical world of appearances' nature of the universe is an evolutionary adaptation that makes it easier to function and survive in the real actual world of information. We seem to live in simulations of reality produced by our own brains and

stored as neural data structures and processes. The real actual world is analogous to a virtual reality which appears physical and dimensional only in the minds of observers.

1. The theory of Relativity is widely tested and confirmed by GPS, ISS etc. However, its fundamentals are often misunderstood. Everything in the universe exists in a common current universal present moment. But within this common present moment clock times run faster or slower depending on their spatial velocity.
2. Everything in the universe continually moves through spacetime at the speed of light in vacuum, c. If things move through space, their velocity through time decreases so their total spacetime velocity always remains equal to c. This is the key to relativity.
3. Because everything moves through spacetime at the same velocity c, everything continually moves the same distance through combined space and time as everything else. This identical distance everything moves through spacetime is the universal current present moment. This is effectively an 'absolute time' that is the same for everyone in the universe.

1. The universe uses the same large number of processor cycles to simultaneously compute the space and time velocities of all processes in every tick of present moment time. This automatically computes a relativistic universe with the fixed number of processor cycles per tick setting the value of c.
2. Likewise, the universe randomly conflates a small number of space and time cycles for each separate process as it computes it. This, in itself, computes a quantum universe in which simultaneous space and time measurements are uncertain below the quantum scale, and in which particles take the form of wave functions.
3. In this way the universe computes a universe that is simultaneously relativistic at the classical level, and quantum at the particle level.
4. This opens a path to the long-sought unification of relativity and quantum theory.

1. The key to including general relativity in the theory is to model masses as fields of intrinsic spatial velocity in the form of hyper-fine vibrations of space itself.
2. Objects within these gravitational fields experience their spatial velocity and this results in their gravitational time dilation. Thus, the total spacetime velocity of objects in gravitational fields remains equal to c.
3. The spatial velocity gradients within the field produce velocity vectors that result in the pull of gravity, in gravitational attraction.
4. This model of gravitation results in a functionally equivalent but much simpler model in which curved spacetime is replaced with a 4D spacetime that is flat, but velocity densified.
5. The model also explains why mass-energy is conserved. The conservation of mass-energy is simply the conservation of equivalent amounts of different forms of spatial velocity.
6. This model also explains *why* the presence of mass-energy 'curves' spacetime, something missing in the usual interpretation of relativity.

1. A pre-existing dimensional spacetime does not exist. Dimensional spacetime is an emergent structure created from the dimensional aspects of particle interactions in aggregate.
2. All particle interactions (with a few rare exceptions) exactly conserve the total sums of each of their particle properties.
3. Thus, the result of continued particle interactions throughout the life of the universe is information relationships among all particles on each of their particle properties. This includes their dimensional particle properties, such as mass-energy, momentum, spin, parity, etc.
4. Thus, continuing particle interactions construct a universe of dimensional relationships among all particles. It is these dimensional relationships in aggregate that we and our science interpret as a dimensional spacetime.
5. In this way the universe computes all particle interactions in a way that creates a quantum universe at the particle scale where each particle interaction is also scaled by the presence of mass-energy which simultaneously results in a relativistic universe at the classical scale, thus unifying relativity and quantum reality.

1. In this dimensional spacetime created by particle interactions and consisting of dimensional fragments with dimensionalities inherently random with respect to each other, quantum processes are no longer paradoxical.
2. They are simply the logical result of randomly knitting together dimensional fragments that are inherently uncertain with respect to each other as dimensional spacetime emerges.
3. E.g., In the standard spin entanglement ‘paradox’, the spin dimensionality of the spin orientations of the two particles are conserved by the particle interaction that created them, and thus fixed at creation within the dimensional fragment of their coherent process, but the overall dimensionality of this fragment is uncertain with respect to that of others including the observer. But when one spin is measured the entire dimensionality of the dimensional fragment of the spins decoheres with that of the laboratory, so that a subsequent measurement of the spin orientation of the other particle will always be found to be opposite of that of the first no matter what that was.
4. So, there is no ‘faster than light’ communication between particles, and no ‘non-locality’.
5. And particles are not ‘everywhere at once’ within their wave functions. Wave functions are simply descriptions of how dimensional fragments are inherently uncertain with respect to each other prior to decoherences in new particle interactions.

THE UNIVERSAL SEA OF EXISTENCE

1. First, we need an explanation of existence itself. What is the difference between what exists and what does not exist? The simplest straightforward explanation seems to be that

the universe consists entirely of a *universal sea of existence*, and *the forms of existence* that exist within it.

2. The universal sea of existence consists of the medium or substrate, the energetic non-material 'substance' of existence itself. All the forms of existence that exist within it are the real and actual things of the world because they manifest the energetic existence of which they are forms.
3. This universal sea of existence is what science calls the *quantum vacuum*. It is the source of all particles, and thus the source and support of the entire observable universe.
4. The universe, the universal sea of existence, the quantum vacuum, and all the forms that exist within it, are all that exists and other than this not even nothing exists.
5. The universe has 'always' existed so there is no need for a creator or creation event. The big bang was an *actualization event* of observable forms of existence within the universal sea of existence, the quantum vacuum.
6. *The universe is alive* in the sense that it manifests continuous *happening* that has no external source.
7. By analogy think of the innumerable forms of water that exist and interact within an otherwise formless sea of water having been being set into motion by the injection of a vast energetic event.
8. The *Tao* was an ancient recognition of the living sea of existence, and the forms that exist within it, though the modern understanding of these forms differs.

THE FORMS OF EXISTENCE

1. The elemental information forms of existence are those of the elementary particles and their particle 'properties', which include rest mass (the gravitational charge), the other force charges, spin, parity, number (identity), and their possible values. All other forms are *emergent combinations of aggregates* of these elemental forms produced according to the rules and constants of the *complete fine-tuning*. These are the atoms, molecules, and the observable universe they compose.
2. The actual elemental forms that completely encode the observable universe include those of both the *intrinsic particle properties* of all particles in the universe, and the *variable particle properties* values that distinguish between particles of the same type. This information is sufficient to describe the complete exact current information state of the entire observable universe, and enable the computation of the subsequent current information state of the universe from it.
3. All these forms clearly have information content, namely the complete, exact distinguishable characteristics that make them what they are and not anything else. Information is precisely what makes things different or identical. Then in addition there is what makes them the real actual extant things that they are. This is their common underlying component of existence of which they all are forms. It's the universal medium of existence that makes all things completely, exactly the real, actual, extant things they are the information of.

4. Note that the complete exact information of particles, and everything else isn't the information of how humans describe them, but the actual information of how the universe encodes and stores them in order to compute their actions and interactions.
5. Just as with computer code, it's conceivable that the information content of the particles and particle properties and the entire observable universe ultimately reduces to patterns of on and off bits, call them c's & n's, bits of two elemental forms of existence.
6. Much more on the elemental forms and their interactions in the chapters on quantum reality.

FORMS ARE IN-FORM-ATION

1. All the forms of existence are the complete exact *information forms* of what they are down to the level of all elementary particles and their properties. Thus, the universe consists entirely of information in a universal medium of existence, which gives it the reality and existence, it's the information of.
2. This becomes clear when we truly understand what information is. Information is anything that can be distinguished. Thus, everything in the entire universe that can be distinguished is information. Thus, everything in the universe is information.
3. Modern information theory confirms information is something real and actual, not just some ephemeral abstract characteristic *of* things. Information is real actual discrete distinguishable forms in some sort of medium. Paper is a medium on which words appear in books, magnetic memory a medium in which bits and bytes of computer data are stored, speech is information in the medium of sound waves.
4. So, the information of the forms of the universe must be real and actual as well. It must be somehow encoded by the universe in some universal medium.
5. Since everything in the universe exists by definition, that universal medium must be the universal medium of existence itself, that gives all the information forms that exist within it their own individual existences. Words on the medium of paper in a book can be a story, but that book with its story is also a form in the medium of existence. This makes it a real extant book recording a real story in the real universe.
6. Common sense and physics mistakenly assume things must have some kind of 'self-substances' that make them what they are in addition to their information. But if there are such self-substances that make things different from each other, they are in turn just additional characteristics, and thus just additional forms of information. So, in the end every possible distinction that makes things what they are reduces to just one more form of information.
7. When all possible distinctions are accounted for the only thing left is what all real things have in common, and that is their existence. Thus, existence is the universal medium in which all the information forms of things exist in common.
8. This is reminiscent of the Vedic belief that the world consists entirely of forms, and all forms are empty of all but Brahman.

INFORMATION & EXISTENCE

1. It's clear from cognitive science that the entire world, *as we experience it,* exists as neural data structures and processes in our brains. The world of our experience is an *active simulation of reality* created by our own minds. It's a virtual reality. It consists entirely of information continually updated by sensory information sampled and reformatted from the information of the actual world. This is of course only possible if the actual external world consists of information as well.
2. This is easily confirmed simply by analyzing our experienced world with an open mind. We quickly realize everything we experience around us, and ourselves and other beings as well, are all the complete exact information of what they are. After all *only information can be experienced, and all that can be experienced is information*.
3. This realization changes nothing about the actual world or the world of appearances. It remains exactly as it was.
4. Information is not just colorless bits and bytes in computer memories. Look around you at the world. Colors are information, brightness is information. Sounds and odors and touches and tastes are all information. Textures and shapes are information as well. And so are all our internal and external feelings, emotions, thoughts, actions, purposes and meanings. Absolutely everything and anything that can be named, discriminated or identified, must, by definition, be a form of information.
5. And we and all other beings are information complexes as well. We are all the complete exact information of what we are and how we live and what we do.
6. And the great sweeps of history and evolution are information as well, though we humans only experience their present moment states and effects.
7. So, when we experience the world, and ourselves within the world, it's absolutely clear we are experiencing an enormously complex interleaved hierarchical network of different sorts of information, and that's all we are experiencing and all that can or could ever be experienced. It's literally impossible to experience anything other than information. All is information, end of story.
8. However, all this information must exist for it to be present and to be experienced. All the information of the universe exists, as opposed to all the possible information that doesn't exist, and this is best explained by all extant information being actual information forms that exist within a universal medium or substrate of existence that pervades and defines the universe, namely the quantum vacuum.
9. What exists, exists in the universal medium of existence in the present moment. Even being hit by a bus is entirely the complete information of what it is made horribly real by occurring in the real world of existence.
10. So, the universal medium of existence itself, the quantum vacuum, is the universe, and existence including all the information forms of existence that exist within it are the totality of the universe. Other than existence, not even nothing exists.
11. This is true of both our mental simulations of the universe, and of the universe itself. Both are the complete exact information forms of what they are in the universal underlying medium of existence itself. This is what our minds tend to think of as the individual self-substances of things. It's only information that makes things different, and it's only existence that makes those differences real, actual, extant, and observable.

12. Even if there were individual self-substances of things, that would be just be one more form of information. It's just the persistent illusion of our mind's simulation of things that causes us to believe otherwise.

THE COMPUTATIONAL UNIVERSE

1. Though everything is information, events clearly occur according to the laws of physics, chemistry, biology, etc., namely the application of forces, the flows of energy, the interaction of charges, etc. But for events to occur according to exact repeatable rules throughout the universe they must do so based on the presence of information that encodes those rules.
2. Thus, the information that defines these rules must be present throughout the universe, it must be encoded into the fundamental fabric of the universe itself. For the laws of nature to be the same everywhere events must take place according to information encoded virtually throughout the universe. (Virtually meaning observable only by their effects on the observable universe rather than directly).
3. *Events taking place according to laws encoded as information is computation by definition.* Thus, the universe must, by definition, be a computational system, the universe must be a computer.
4. This realization doesn't change anything, physics works exactly as it did before, it just explains how the universe works the way it does at the most fundamental level. The universe works as it does only if it can be exactly computed on the basis of the exact complete information that it, and everything within it, actually is.

THE COMPLETE FINE-TUNING

1. Computer science shows what the necessary elements of a computational universe must include. This can be called the complete fine-tuning.
2. First, the complete data of all the particles and particle components in the universe must be encoded. Certainly, all the elementary particles and particle properties must contain their complete exact information, otherwise they could not be what they are, or repeatably act and interact as they do, even according to a traditional mechanistic non-computational interpretation of physics.
3. And second, all the necessary elements necessary to compute the continuing actions, interactions, and evolution of all the particles in the universe must be themselves encoded in the form of virtual information.
4. Thus, all necessary information must be encoded in the virtual fabric (data space) of the universe, and a universal necessary and sufficient set of universal rules and procedures that enables its computations must also be virtually encoded in the structure of the universe itself.
5. So, there must be an *elemental program* that computes particle interactions, and there must be all the logical rules and operators by which the elemental program operates, and

there must be a *universal processor* that simultaneously drives all the individual instances of the elemental program to simultaneously compute all the coherent processes of the universe and their interactions.

6. For the universe to remain consistent, all processes must be computed independently and simultaneously in *each tick of present moment time,* each by a separate instance of a single elemental program, and this *must produce both a relativistic and a quantum universe.*
7. Thus, the universe is a *massively parallel multiprocessor system* that continually computes the interactions of the information of all elementary particles, and thereby, the continuous evolution of the entire observable universe.
8. The universal processor is the ultimate source of all process, time, motion, change, life, evolution, and even consciousness. It is the fundamental process and beating heart of the universe. The sequence of present moment time ticks creates the *arrow of time,* not entropy as is often mistakenly supposed. Entropy varies widely throughout the universe depending on the local balance of forces, with no correlation to the local flow of clock time.
9. Thus, the observable universe is a computed information structure in a similar sense to a virtual reality. It exists in a *non-dimensional data space,* just as other virtual realities, and only assumes its emergent form as it's experienced in the minds of observers.
10. Our consciousness in a present moment through which clock time passes is our direct experience of this most fundamental process of the universe taking place within our own being.

THE VIRTUAL & OBSERVABLE UNIVERSE

1. The information within the sea of existence is of two types, virtual and observable. The fundamental forms of *observable information* are the elementary particles and their properties, which are observable because they interact with observers. The *virtual information* is observable only by its effects on the observable information. It consists of all information necessary to create, compute and support the observable information and its interactions. This is the complete fine-tuning.
2. The totality of observable information makes up the *observable universe*. Science has begun to discover the *virtual universe* in what it calls the *quantum vacuum*. The virtual information consists of the elemental program, and all logical rules and constants necessary to compute the observable universe.
3. This model easily solves the perceived problem of Penrose and others of how nonphysical laws of nature somehow control an apparently physical universe.
4. The virtual and observable universe are not separate, but two inseparable aspects of the single sea of existence. The quantum vacuum exists everywhere and everywhere supports the observable universe within it.
5. Thus, in effect, the universe is a virtual reality computer in which a universal program continually computes the evolution of the observable universe. The entire system consists only of information forms in a universal medium or substate of existence which gives it all its actual reality.

6. Information forms can only exist in a medium that can manifest them.
7. The medium of existence must have a virtual implicit information structure. Just as the possible forms of water are determined by the nature of water. These can only be the virtual information which governs its observable information.
8. So, it's reasonable to assume that the fundamental forms and rules governing them are somehow determined by the nature of the substrate of existence itself, and therefore our complete fine-tuning is the only one possible. It's certainly true that the consistency of its logical rules probably makes those the only set possible.
9. So, our complete fine-tuning is most likely to only one possible. The notion that because we can imagine others and haven't yet discovered why all the details of ours exist, that there must therefore be a ginormous number of other actual 'metaverses', each with exactly one of all other imaginable possible sets of complete fine-tuning rules is laughable. The only evidence for 'metaverses' seems to be the current ignorance of cosmologists.

THE UNIVERSE IS LOGICALLY CONSISTENT

1. If the universe is a computational system, it must be logically consistent and logically complete. Its computations must always be able to compute a subsequent state, it's computations can never halt, and it can never be able to compute a contradiction. Thus, it must proceed from a set of internally consistent axioms, operations, and operators. If it were able to compute a contradiction it would tear itself apart, and could not exist.
2. *Existence exists*, is he single most fundamental self-referential and tautological axiom of the universe. The most fundamental axiom must be tautological – otherwise it would always depend on something else. 'Existence exists' is the 'bottommost turtle'.
3. *Existence is differentiable* is the 2nd fundamental axiom. The single fundamental 'substance' of existence is resolvable into discrete, different, differentiable forms of existence. Thus, the substrate of existence has an inherent virtual structure within it sufficient to give rise to the entire observable universe.
4. For existence to be differentiable there must be logical and actual 'spaces' in which different forms of existence are able to be differentiated and separately exist. These are the symbolic space in which the various operators and rules necessary to compute the universe exist, and the actual spacetime continuum in which the information results of these computations have 'room to exist' by not being all at the same place and time.
5. Thus, the universe must consist of a spacetime continuum within which individual particles and particle properties have 'room' to exist, and a logical space of all rules necessary to compute the existence and evolution of that structure, the complete fine-tuning. In turn, the logical rules of the complete fine-tuning must themselves be entirely consistent, and unable to compute contradictions.
6. Gödel's incompleteness theorems don't apply here, nor does the Turing halting problem. These postulate the inability to prove certain well-formed statements in logical systems, but the universe doesn't go around trying to prove statements, it just

continually computes subsequent states from previous states based on consistent rules of logic. However, it is possible the universe might never compute some states that are consistent with its axioms.

7. The rules of universal logic are a necessary part of the complete fine-tuning, and will constrain the complete fine-tunings possible, perhaps even to the single actual complete fine-tuning of our universe.
8. This necessary internal logical consistency falsifies a number of apparent paradoxes, such as time travel to an actual past in which one could theoretically kill one's mother before one was born. This is automatically impossible because it results in a logical contradiction. Likewise, the existence of singularities in which the 'laws of physics break down' at the center of black holes. These and more are forbidden in a consistent computational universe.
9. However, many apparent paradoxes, such as the so-called quantum paradoxes, aren't actual paradoxes, and are simply resolved in CTOE by an advanced understanding of quantum reality and its unification with relativity as will soon be explained.
10. Of course, individual humans can mentally compute contradictory thoughts, but this is only possible when false premises are assumed, incorrect logic is used, or the veracity of facts is unknown.

THE IMMANENCE OF EXISTENCE

1. Everything actual is *absolutely exactly what it is to an unlimited degree* and is entirely a manifestation of pure absolute existence. This is what 'pops' or 'shines' all things into existence as real actual things, absolutely exactly what they are. This absolute absoluteness of things is the *immanence of things*.
2. This concept of immanence is akin to the Christian concept of immanence, but without any religious symbols or context. It isn't an experience of the Christian divinity in religious symbols, but of the absolute divinity of existence itself in all its possible forms.
3. The ability of an observer to experience the immanence of things is limited only by its own capacity. Realization, defined as experiencing the true nature of things, involves the experience of the immanence of existence within the forms of all things, and the pure formless immanence of mind emptied of thoughts. More in the relevant sections.
4. This intrinsic immanence of things provides an easy solution to the 'hard problem' of consciousness, namely how does a 'non-physical' consciousness arise in a supposedly 'physical' world. Consciousness isn't some complicated combination of mental or even quantum processes, it's simply the absolute immanence of things being experienced. More later.

TIME & SPECIAL RELATIVITY

1. The key principle of special relativity is that *everything that exists continuously moves through spacetime (combined space and time) at c, the speed of light in a vacuum.* This continuous *c spacetime velocity of everything is the active motive force of the universe*. It's the direct computational source of all happening, change, motion, time and evolution.
2. As a result, *everything is always traveling the same distance through spacetime from one current universal moment to another*. More precisely, all timelike paths between two events have the same spacetime length. (A timelike path is a path traveling through spacetime from the past to the future.) These principles are provably true though many novice relativists don't understand them.
3. This is true in actuality and in the individual views of all observers of other things. If there is any spatial velocity, the default c velocity through time is reduced so the total spacetime velocity always remains equal to c, otherwise everything advances through time at the speed of light. This slowing of time with spatial velocity is called *time dilation.*
4. Since the 4 dimensions of space and time are orthogonal (at 90 degrees to each other) the sums of time and space velocities and distances are *vector sums* given by the squares of the individual velocities and distances. Vector sums give the *direction* in spacetime as well as its *arithmetic sum* of the results.
5. The equations here are quite simple $v_s^2 + v_t^2 = c^2$, spatial velocity squared plus temporal velocity squared equals the speed of light squared, where the velocities are vectors in the 4D spacetime continuum. And $\tau^2 = t^2 - d^2$, the distance through time of an observed clock (its time dilation) squared equals the square of the time on the observer's clock minus the spatial velocity squared of the observed clock.

UNDERSTANDING SPATIAL VELOCITY

1. But, to properly understand how these principles work one must properly understand spatial velocity.
2. Spatial velocity is relative. If A is moving relative to B, then B is moving relative to A at the same velocity in the opposite direction. In this sense spatial velocity is relative and there is no absolute spatial velocity. Thus, by the equations above, both A and B see the other slowing in time due to their perceived relative spatial velocity. But this isn't the whole story.
3. In the classic 'Twins example', twin A stays on Earth, while twin B takes a space trip at relativistic speeds, turns around and returns to Earth. On reuniting the twins find that B has aged considerably less than A due to his spatial velocity. Traveling a greater distance through space at a greater spatial velocity means B traveled a shorter distance through time and thus compared to A his velocity through time was slower.
4. Both traveled the exact same total distance through spacetime at the same c velocity. But because B traveled further than A through space, he necessarily traveled a shorter distance through time at a slower relative rate.

5. The relative spatial velocity of the twins was equal, though opposite, during the trip, so why did only B actually age less because he traveled a shorter distance through time?
6. The key is that *spatial velocity relative to an original inertial path* is what results in *actual versus observational time dilation*. During the trip both A and B observed the other's clock running equally slower, but upon B's return only B's clock had actually passed less time. The fact that B deviated from the original inertial path he shared with A and the Earth is why. A didn't deviate from that path and so he experienced no actual time dilation.
7. As John Baez of Caltech says, "Time dilation is caused by deviation from an (original) inertial trajectory." Deviation from an original inertial path is *actual spatial motion since it results in actual spatial velocity relative to itself,* as opposed to the *relative spatial motion* of objects moving with respect to each other. *Actual spatial velocity is relative to one's own previous spatial velocity,* not just relative to other observers. It's real because it's always the result of an *actual tangible acceleration*.

THE UNIVERSAL PRESENT MOMENT

1. The other important lesson of the Twins example is that even though B experienced actual time dilation, and A didn't, they both reunite in the exact same present moment. So clearly there is a present moment time which is not the same as clock time.
2. So, the clock times and distances in time, and spatial velocities and distances A and B traveled, are different, but what is the same to explain them meeting in the same present moment? Clearly, it's the fact that they both traveled the exact same distance in combined spacetime. In fact, it's clear that since everything in the universe continually travels the exact same distance through combined space and time at a constant combined space and time velocity of c, that everything in the universe must continually be in the same current universal present moment.
3. Thus, there is a single common current universal present moment in which individual processes may have different spatial velocities and clock time rates but all sum to c.
4. Thus, the definition of the *universal present moment is the identical distance* everything in the universe has moved through combined space and time in each tick of present moment time irrespective of current clock times or spatial velocities.
5. And this is the proof that a universe present moment or 'now' does in fact exist. This seems to be original with CTOE, and not understood by anyone else.

HOW THE PROCESSOR COMPUTES A RELATIVISTIC UNIVERSE

1. If the universe is computational, how does it compute a relativistic universe? The following model provides a good explanation of how this might happen, so it's likely close to the truth.
2. Assume the universal processor uses the same very large (to diminish granularity of results) fixed number of ultra-short cycles to separately compute each coherent process in each tick of present moment time. Each tick being much shorter than the shortest particle process it computes.
3. It first uses cycles necessary to compute any spatial velocity of the process relative to its original inertial path, then uses the remaining cycles to compute its temporal velocity.
4. Its spatial velocity changes its location relative to its original inertial path, and its temporal velocity evolves the process itself.
5. This allocation of processor cycles between space and time velocities automatically creates a relativistic universe in which every process continually moves through combined space and time at c. The greater the spatial velocity, the less velocity though time, so the total spacetime velocity always equals c.
6. In addition, the fixed number of processor cycles conveniently becomes the source of the value of c.
7. Note that this inherently creates a universe that is spacetime granular at its fundamental scale, presumably far below the limits of measurability, unless the granularity is somehow magnified by some higher scale processes.

MASS-ENERGY AND GENERAL RELATIVITY

1. The various forms of spatial velocity are the various forms of mass-energy. Mass-energy is spatial velocity is mass-energy. Thus, the fabric of the observable universe consists of temporal velocity and mass-energy in the form of spatial velocity.
2. Further, a new model of the nature of mass greatly simplifies general relativity, the conservation of mass-energy, and the universe itself.
3. If we assume that masses are actually fields of spatial velocity, of fields of hyper-fine vibrations of spacetime itself, we get a simplifying explanation of gravity, the conservation of mass-energy, and of gravitation time dilation. Objects passing through such fields would experience their spatial velocity and their velocity through time would slow.
4. This provides a new explanation of how gravitational time dilation arises in general relativity. These fields of intrinsic spatial velocity are functionally equivalent to the curved spacetime of general relativity. When vibrating paths are smoothed, they elongate and curve and one gets the familiar curved spacetime of general relativity.
5. Also, it becomes clear that mass and energy are conserved because equivalent amounts of these different forms of spatial velocity can be converted into each other. This provides the missing why of mass-energy conservation.
6. (Note that potential energy isn't a form of spatial velocity because it's really just an accounting trick used to make it easier to compute the mass-energy of systems in isolation.)

7. This is how the universal processor automatically computes an observable universe with both special and general relativity.

ACTUAL & OBSERVATIONAL VIEWS IN GENERAL RELATIVITY

1. Consistent with special relativity, in general relativity, actual views are those from frames in empty space with no gravitational time dilation due to the presence of gravitational fields.
2. For example, an oft-stated principle of relativity, is that the speed of light is the same in all frames.
3. But the speed of light is not actually the same everywhere. In fact, it varies from c in empty space to zero within a black hole.
4. However, all observers measure the speed of light as c in their own frame because their clock time always slows by the exact same amount as light. An observer falling into a black hole thinks light is still traveling at c because the clock by which he measures velocities is slowing by the same amount.

BEYOND CURVED SPACETIME

1. This new view of gravitational mass fields as intrinsic spatial velocity densities enables us to replace the standard curved space model of general relativity with a superior model that produces identical mathematical results.
2. In this model 4D spacetime is flat and geodesic curves are replaced with areas of velocity densified space.
3. The equivalence It's easy to visualize. First, simply compress all general relativistic geodesic curves through a curved spacetime along their lengths until they become straight lines in a resulting *flat* 4D space. The compressions produce hyper-fine identical-phase waves with amplitudes a function of the local curvature of the geodesic. Now set these waves into motion as vibrations with intrinsic spatial velocity equivalent to their amplitude. Objects traversing these vibrational waves must ride up and down the waves, traversing the identical lengths of the now compressed geodesics.
4. The spatial velocity of these vibrations will produce the correct gravitational time dilation of objects within their field, and the increasing spatial velocity of points toward the center of mass will produce velocity vectors that correctly model gravitational attraction.
5. This new model of masses as fields of intrinsic spatial velocity also explains *why* masses 'curve' spacetime, something relativity has been unable to do.
6. In addition, this flat velocity-densified spacetime has the great advantage of making the universe much simpler and easy to compute than a curved 4D space.
7. Actually, these vibrations must take the form of spherical expansion-contraction pulses at every point in the previously curved space of amplitude equal to the previous curvature. This is necessary to avoid any preferred spatial orientation implied by sine-type waves.

THE QUANTUM UNIVERSE

1. In our universe there are 29 known types of elementary particles that make up and control the interactions of all matter in the observable universe.
2. There are six quarks - up, down, strange, charm, top, bottom. Six antiquarks of the same name, six leptons - electrons, electron neutrino, muon, muon neutrino, tau, and tau neutrino, six antileptons of the same names. Four bosons - photon, two W bosons and one Z boson, three gluons and their anti-gluons, and one scalar boson, the Higgs boson.
3. Each type of elementary particle is characterized by a unique set of particle properties with fixed values which defines them. These include rest mass (the 'charge' of the gravitational force), the several other force charges, spin, parity and a few others.
4. In addition, individual particles have a set of *variable particle properties*, such as energy, momentum, and spacetime locations which are relative to measurement frames, which differentiate individual particles, and allow for the existence of vast multitudes of individual particles of these 29 types.
5. Now, because many particles can be transformed into other types of particles in particle interactions, but the sum of the number of each individual particle property type is always conserved, (with a few rare exceptions), it is *logical to consider the particle properties themselves as the fundamental elementals of the universe*, the fundamental information forms.
6. Even though particle properties cannot exist in a 'naked' state, on their own outside of particles, this makes perfect sense, as it effectively continues the historical reduction of everything towards more and more elemental components down through substances, chemicals, molecules, atoms, composite particles, elementary particles, and now ultimately particle properties, all as forms of information.

PARTICLE INTERACTIONS

1. Most of the richness of our universe comes from particles constantly interacting. The rules of the complete fine-tuning allow this on a universal scale. Some particle interactions change only the variable dimensional properties of individual particles such as energy and momentum; while others transform some types of elementary particles into other types.
2. But it's a basic rule of the complete fine-tuning that particles can only transform into other types of particles when all particle properties are used up to form the new particles. There can be no 'naked' particle properties left over outside of particles. This greatly restricts the type of particle interactions that can take place, and results in a relatively orderly universe.
3. Thus, the basic rule of particle interactions is that the *sums of the values of all particle properties are always conserved in all particle interactions* (again with very rare exceptions). This is key to understanding the quantum universe.

4. Note that it isn't the number of particle properties that is conserved, but the sums of their values by type. In extreme high energy particle collisions, such as those produced at the large hadron collider (LHC), scores of new particles with hundreds of new particle properties are produced from the collision of just two initial particles. However, the *sum of the values* of all those new particle properties will always equal those of the two initial particles. It is the sum of the values of individual particle property types that is conserved, not their numbers.
5. There are two subtypes of particle properties. Most, such as parity, spin and the non-gravitational force charges come in a very small number of plus and minus values of small integers or fractions. In contrast, particle rest masses are always positive, and have seemingly arbitrary and unrelated larger values.
6. However, the particle property conservation rules always hold. The sums of the resulting individual particle property values of both subtypes always equal the sums of their initial values of the interacting particles. But in the case of rest masses, it's rest mass plus energy that is conserved.
7. So, it appears the universal sea of existence, the quantum vacuum, serves as a reservoir of 'naked' particle properties, and when sufficient energy is applied, valid sets of these particle properties can combine to form real actualized particles that 'pop' into existence in the observable universe.
8. So, presumably this is what occurred in the big bang. An amount of pure energy equal to the universal total appeared in the quantum vacuum where it actualized all the particles in the universe in successive stages of heat (relative spatial velocity) which formed more and more stable particle populations as it expanded and cooled, as average relative spatial velocity lessened. More on the big bang in the next section.
9. If particles with equal and opposite particle properties (particles and antiparticles) interact their particle properties cancel out, and the particles annihilate, leaving just their pure energy remaining in the actualized universe.

QUANTUM ENTANGLEMENT

1. Popular discussions give the impression that *entanglement* is a mysterious phenomenon that only occurs in particular 'paradoxical' cases but this is untrue. Entanglement is actually a universal consequence of particle interactions and it occurs at the classical scale as well.
2. Property understood, entanglements are simply the relationships formed among the conserved components of interactions, at both particle and classical scales.
3. *Entanglement* is the interrelationships formed among the properties of the resulting parts of a conservation event at any scale. For example, the two pieces of a broken chocolate chip cookie are entangled on their chocolate chips because chips were conserved in the break and thus the sum in both pieces equals the number in the original cookie. Thus, the number in either piece determines the number in the other piece.
4. When there are more than two resultant components, such as a cookie breaking into three or more pieces or more than two particles resulting from a particle interaction, the entanglement relationships are more complex, but still exist.

5. Thus, *every interaction* of whatever type in which components are conserved is properly an entanglement event. This includes *every* particle interaction, since all particle interactions conserve their particle components.
6. So, particles become entangled with the particles they interact with on each of their conserved particle properties individually. In turn, those particles interact with other particles and so on. The result, over the life of the universe, is the creation of a single vast *particle entanglement network* that most likely includes all particles in the universe.
7. So, the particle properties of all particles in the universe likely have some degree of entanglement relationship among their particle properties. We can reasonably assume all particles in the universe compose a vast information background with respect to which all particles and particle interactions in the universe are relative to.
8. It is likely this universal background is what absolute rotation (Newton's bucket), and relativistic spatial velocity (original inertial trajectories) are with respect to. This is likely what Planck's proposed 'background mass' of the universe actually is, because it forms a universal background of dimensional and other relationships that all particle interactions take place relative to.
9. The entanglement network is the current computational result of all particle interactions in the history of the universe, and is the fundamental information structure of the observable universe.
10. The entanglement network is *intrinsic* in that its information is stored entirely in the particle property values of individual particles, rather than explicitly as a separate information structure.

HOW THE PROCESSOR COMPUTES A QUANTUM UNIVERSE

1. A *coherent process is defined as the computational interrelationships among all resultant component particles and particle properties of a particle interaction prior to any subsequent interactions that alter them*. These interrelationships must be exact because they are produced by the exact conservation laws of the interaction, and they must continue to be exact unless altered by subsequent interactions.
2. As we have seen, every coherent process is simultaneously computed by a separate instance of the elemental program.
3. Now if we assume every universal processor computation *randomly conflates a relatively small fixed number of spatial velocity and temporal velocity cycles*, this single factor is sufficient to generate the quantum randomness of the observable universe at the particle scale.
4. The scale at which this space versus time cycle conflation occurs is *h*, the value of the Planck constant, which scales most quantum equations.
5. This conflation produces the Uncertainty Principle, $\Delta x \times \Delta p \geq h/4\pi$, because it makes it intrinsically impossible to simultaneously measure time-based and space-based variables with unlimited accuracy below the scale of *h*.
6. And this same conflation will generate particles in the form of wave functions whose time and space locations are intrinsically probabilistic. [Note that the Schrödinger wave function equation that describes particle paths has an exact spacetime trajectory itself. It

is only the 'location' of the particle within its wave function that is probabilistic. This implies that the particle may be exact within an underlying computational space, and only probabilistic with respect to an emergent dimensional spacetime. This is consistent with other aspects of CTOE]

7. In this way, the universe is computed to consist of innumerable coherent processes whose time and space locations are intrinsically random with respect to one another at the quantum particle scale. Non-dimensional particle properties are not affected and remain exact to all even through subsequent interactions.
8. Since dimensional spacetime is emergent from particle interactions, these coherent processes are in effect *dimensional fragments* from which emergent spacetime is constructed.
9. This is how the conflation of space and time velocities at the Planck scale by the universal processor as it computes particle interactions could automatically generate the uncertainty of the quantum world.

DECOHERENCE

1. So, the processor computes the observable universe in the form of a universal entanglement network in which all coherent particle processes are dimensionally uncertain with respect to each other at the quantum particle scale.
2. But for further particle interactions to take place all particle properties must be conserved, and conservation of particle properties can only occur if they all have exact values, including dimensional values, with respect to one other.
3. Thus, when particles interact, they undergo a random *decoherence*, which means they randomly take on exact dimensional values with respect to each other. Only decohering to exact dimension particle property values enables them to be exactly conserved in the interaction.
4. When particles decohere, and become dimensional exact with respect to each other, they produce a new dimensionally exact coherent process, a new dimensional fragment, and this new coherent process is now computed by a single new instance of the elemental program with its own new unique random conflation pattern.
5. Thus, it too becomes dimensionally randomly uncertain with respect to all other coherent processes, and this overall process continues through innumerable sequences of particle interactions.
6. It should be noted that some particle interactions are transient individual interactions, but others such as those that form atoms and molecules, are persistent, or *bound interactions*.
7. But as a general principle, the results of any particle interaction, continue to be computed as a coherent process by a single instance of the elemental program unless or until they interact with and decohere with another particle in a subsequent interaction forming a new coherent process, a new dimensional fragment, with its own new dimensional randomness with respect to others.
8. This dimensional fragment model resolves the apparent paradoxical nature of quantum processes as we will soon see in the case of spin entanglement, and *it is testable*. It the

separate particles produced by a particle interaction are found to be coherent and dimensionally exact with respect to each other prior to any subsequent interactions.

COMPUTATIONAL SPACE

1. The universal entanglement network is the *computational space* of the universe. It's the data the universe uses to continually compute its evolution in every tick of present moment time. It's essentially the 'computer memory' of the universe. As with virtual realities this computational space is not itself dimensional, not itself a 4D continuum, but rather, the current particle property information, including dimensional relationships, of all particles in the universe resulting from their cumulative particle interactions since the big bang.
2. The data is stored as the current present moment individual values of all particle properties created by particle interactions throughout the history of the universe. It's the values of all particle properties relative to the particles they have interacted with, rather than 4D values relative to a pre-existing spacetime which doesn't exist.
3. Because particle properties are conserved in particle interactions, the relative values of particle properties in the coherent process resulting from a particle interaction, prior to subsequent interactions, are exact with respect to each other. However, the dimensional particle properties of non-coherent processes have a quantum uncertainty with respect to each other due to their being computed by different instances of the elemental program, each using a different random conflation of space and time cycles at the quantum scale.
4. Note this is consistent with relativity, in which all dimensional values are actually relative to observer frames rather than any fixed background.
5. However, the dimensional relationships of particles in aggregate tends to approximate, or coalesce towards a consistent 3D classical and even cosmic scale background structure relative to which subsequent particle interactions take place, that is still quantum uncertain at the Planck scale.
6. Now, because the cosmic scale dimensionalities of computational space continually coalesce from particle interactions in aggregate, it's possible these background dimensionalities could vary in different regions of the universe, especially where conditions were different, or even gradually change over time in the same region. I refer to this possibility as *dimensional drift*.
7. Observationally this might lead to slight apparent animalities in various dimensional measurements, in particular relativistic measurements. The Pioneer anomalies, or even unexplained aspects of dark matter and dark energy might be signs of dimensional drift. And the relational dimensional nexus of computational space is presumably what rotation, and the original inertial path seem to be relative to, to apparently anomalous aspects of those as well.

HOW PARTICLE INTERACTIONS CREATE DIMENSIONAL SPACETIME

1. All these computational processes occur within the pre-dimensional computational space of existence in the same sense that dimensional space in a virtual reality is computed in a pre-dimensional computer memory, and only appears as a dimensional spacetime in the view of an observer.
2. What our minds, and our science, interpret as familiar dimensional spacetime, is an evolutionarily adaptive 3D mental graph of the *dimensional relationships implicit in the entanglement network*, in particular a mental graph in which it places classical scale particulate objects according to their dimensional relationships.
3. Our minds simulate these dimensional relationships as a single encompassing dimensional spacetime within which objects are placed according to their dimensional relationships. Our minds then reify this simulation and project it out around us into the familiar dimensional spacetime in which we imagine we exist.
4. Empty dimensional spacetime itself cannot be observed and does not actually exist, only dimensional relationships among objects can be observed, and these are all ultimately produced by particle interactions as we have seen.
5. So, dimensional spacetime is a convenient evolutionary adaptation that greatly simplifies our interaction with and ability to function in the world. It enables us to deal with the relative positions, sizes and orientations of all present objects within a single coherent framework.
6. Thus, *particle interactions can be said to create dimensional spacetime*, and *dimensional spacetime is not a pre-existing stage or container for events* as currently imagined.

UNIFYING RELATIVITY & QUANTUM THEORY

1. Understanding that there is no pre-existing dimensional spacetime, and that it's an emergent effect created by particle interactions enables us to unify relativity and quantum theory. Their seeming incompatibility is primarily due to both mistakenly assuming pre-existing spacetimes that are intrinsically incompatible; quantum theory a fixed spacetime background, and relativity a spacetime that changes with the presence of mass-energy.
2. However, when we understand that there is no pre-existing spacetime, and what we need to do is calculate the dimensional values of particle interactions and scale them by the presence of mass-energy fields, then we see that the relevant quantum equations must actually include such scaling terms. The problem is that those scaling terms are negligible at the particle scale so they haven't been discovered. But when included they should properly describe dimensional relationships among particles that are quantum at the particle scale, but relativistic at the classical scale.
3. So, the apparent incompatibility between relativity and quantum theory is replaced with particle interactions taking place in a pre-dimensional computational space in which the resulting dimensional relationships are simply scaled by the presence of mass-energy.
4. Because this relativistic scaling takes place at the particle scale it's too fine to measure and only becomes measurable when large particle aggregates are considered.

5. The result is a universal entanglement network that incorporates quantum uncertainty at the particle scale but also produces relativistic dimensional relationships at the classical scale. This is then simulated as a universal dimensional spacetime populated by objects based on their dimensional relationships by our minds and our science.

RESOLUTION OF QUANTUM PARADOX

1. The current quantum interpretation holds that there is a universal dimensional background spacetime in which all individual particles exist, and those particles exist as wave functions within which their spatial locations are intrinsically random with respect to the common universal spacetime. But this model leads to quantum processes appearing paradoxical.
2. In contrast CTOE proposes there is no common background spacetime, and that what we call dimensional spacetime actually emerges from the dimensional relationships created by particle interactions in the form of dimensional fragments. Because quantum events conserve all particle properties, including dimensional properties such as time, rest mass, energy, momentum, and spin, every particle interaction creates dimensional relationships among the resultant particles.
3. The result is that all particles in the universe develop dimensional relationships among themselves, and this nexus of dimensional relationships is what we simulate as dimensional spacetime.
4. Now because each particle interaction is a coherent process, the universal processor computes each with its own random conflation of space and time processor cycles which results in its internal dimensional relationships being exact but quantum random with respect to those of other coherent processes.
5. The result is that the universal network of dimensional relationships among particles consists of what we can call *dimensional fragments*, each exact within itself, but quantum random with respect to the dimensionality of other dimensional fragments. It is this quantum randomness of dimensional fragments with respect to each other that is accurately expressed by wave function equations, rather than individual particles with respect to a common preexisting dimensional spacetime, which doesn't actually exist.
6. Understanding this is the secret to resolving the apparently paradoxical nature of quantum processes.

QUANTUM SPIN ENTANGLEMENT

1. In the often-cited case of quantum spin entanglement, CTOE provides a simple non-paradoxical explanation.
2. In this case, the spin orientations of two particles produced by a single event must be equal and opposite to conserve spin in the event that produced the particles. However, the particular orientation of those spins is random, could be at any angle, and is unknown until measured. When the spin orientation of one is measured it can be at any random

angle, but then when the spin orientation of the other is measured it will always be exactly opposite. In this way spin is always exactly conserved.

3. This has led to nonsensical theories of faster than light communication in which the first measured particle somehow instantaneously communicates what its spin orientation is to its pair particle and that somehow sets the spin orientation of the other to become exactly opposite. This is referred to as 'non-locality'.
4. The CTOE model of quantum processes provides a simple logical non-paradoxical solution to this 'paradox'.
5. Due to particle property conservation the spin orientations of the particles must be fixed equal and opposite to each other when the particles are originally created, and that includes their exactly opposite orientation in the spacetime of the dimensional fragment of the coherent process in which they are created.
6. However, due to the processor's random conflation of space and time cycles as it computes separate coherent processes, this fixed angle is created uncertain with respect to the spacetime orientations of other coherent processes. Thus, only when one spin is measured does their entire fixed coherent interrelationship angle decohere with that of the measurement device.
7. It's important to understand that with the measurement of the spin orientation of the first particle, the dimensionality of the entire coherent process containing both particles, the entire dimensional fragment, decoheres with the classical scale dimensionality of the laboratory.
8. Basically, this is the same as the cookie. The number of chocolate chips in each half was fixed at the breaking event. There could potentially be any random number (up to the total) in the first piece. But when the number in the first piece is measured then we automatically know what the number in the other piece will be, and it always will be that number when it's measured. Nothing paradoxical at all here!

THE DOUBLE SLIT EXPERIMENT

1. In the classic double slit experiment a stream of particles passes through a barrier with two narrow slits onto a screen. As it hits the screen each particle registers its impact as a tiny dot on the screen.
2. Now, the *pattern* of dots looks like it was made by waves diffracting through the slits and alternately reinforcing and canceling each other out horizontally across the screen. Even if the particles are all fired one at a time, this same wave like pattern is always produced.
3. This is taken as proof that particles are simultaneously waves and particles that are somehow simultaneously everywhere at once within their wave functions.
4. CTOE provides an alternate explanation that provides identical mathematical results.
5. In CTOE, the wave functions that correctly describe particles are not descriptions of 'fuzzy' particle trajectories in a pre-existing static spacetime, but rather descriptions of the inherent dimensional uncertainty in successive single coherent dimensional fragments relative to the classical scale decohered dimensionality of the experiment.
6. Thus, the particles are always point particles, however because they are computed by the processor with Planck scale random conflations of space and time cycles, their

dimensionalities with respect to others is inherently uncertain when it comes to time and space.
7. So, wave functions still provide accurate results, but they don't describe individual particles, but rather the randomness in the dimensionalities of their coherent processes, of their dimensional fragments.

QUANTUM TUNNELING

1. Quantum tunneling is another apparent quantum paradox. Here, a population of particles exists on one side of a solid barrier. Occasionally one of these particles will mysteriously appear on the other side of the barrier as if it had somehow 'tunneled' through it.
2. Again, this taken as further evidence that particles are actually 'everywhere at once' within their wave functions some parts of which extend beyond the barrier. This occasionally allows particles to appear beyond the solid barrier as if they had magically passed through.
3. The error here again is that spacetime is assumed to be an exact fixed pre-existing universal structure, when it actually consists entirely of a universal network of dimensional fragments that are intrinsically random with respect to each other.
4. As these dimensional fragments continually decohere with respect to each other, they continually weave what we call dimensional spacetime. But as particle interactions continue to occur, they continue creating new coherent process dimensional fragments on the quantum scale.
5. Thus, in quantum tunneling, the dimensional fragments of particles and the barrier may occasionally overlap as they decohere, crating the appearance of particles having passed through a solid barrier.

CONCLUSIONS

1. The universe consists entirely of a universal sea of existence, the quantum vacuum, and all the forms of existence that exist within it.
2. All the forms of existence are forms of information, the most elemental of which are the elementary particles and their particle properties.
3. The universe is effectively an incomprehensibly large computational system, a computer that continually computes the interaction of all its elemental information forms. Thus, it continually computes the evolution of the universe.
4. The universe computes its evolution on the basis of the elemental rules of the complete fine-tuning which exist as virtual information used to compute the observable information of the observable universe.
5. All the particle interactions in the universe are simultaneously computed by separate instances of the elemental program.
6. The universal processor computes a relativistic universe by apportioning a fixed number of processor cycles to velocity in space, and velocity in time.

7. And it computes a quantum universe by randomly conflating a Planck scale number of space and time cycles. As a result, the dimensionality of each coherent process is intrinsically random with respect to all others.
8. In this way particle interactions create dimensional fragments. What we call dimensional spacetime isn't a preexisting background 'container' for particle interactions. Instead, particle interactions create spacetime in the form of dimensional fragments.
9. This model opens a path to the unification of relativity and quantum reality.
10. Each computation creates one 'tick' of present moment time in which everything in the universe advances the same distance through combined spacetime. In this way everything in the universe continually stays in the same universal present moment.

II: COSMOLOGY & INFORMATION COSMOLOGY

THE SPACETIME 'FABRIC'

1. The 'fabric' of dimensional spacetime emerges from the conservation of the dimensional aspects of all particle interactions in aggregate as we have seen. It's the universal dimensional aspects of the entanglement network described in the previous section on *Fundamentals*.
2. Once emerged it exhibits classical scale properties of its own ultimately deriving from the complete fine-tuning.
3. The spacetime fabric isn't material, but rather a logico-mathematical structure governing the way measurements and interactions of things work. Nevertheless, it produces actual tangible consequences such as acceleration, gravitation, and collisions of things, which in turn are information forms.
4. If, as explained in the previous section, masses are fields of intrinsic spatial velocity that manifest as gravitational fields, then the entire fabric of the universe can be considered a single field of greater or lesser intrinsic spatial velocity.
5. Every point in this universal field exists in the current universal present moment, and thus every point in the field is advancing through spacetime at c, the speed of light in vacuum. In the absence of mass-energy in empty space there is no intrinsic spatial velocity and all the c spacetime velocity is through time, but to the extent there is mass-energy and its intrinsic spatial velocity, the c velocity through time is reduced so the vector sum of space and time velocities always remains equal to c.
6. Thus, the entire universe is a single field of intrinsic speed of light c spacetime velocity at every point. Objects in spacetime experience the local velocity of this field, and this manifests as gravitational time dilation as previously explained.
7. The intrinsic spatial velocity of these gravitational fields takes the form of hyper-fine dimensionally symmetric vibrations of spacetime itself.
8. All forms of spatial velocity are energy. All mass-energy is spatial velocity in one form or another. Intrinsic spatial velocity in the form of hyper-fine vibrations of space itself is mass, and all other forms of spatial velocity are other forms of energy.
9. *Spatial velocity is mass-energy is spatial velocity*. This is why mass-energy is conserved, it's just the conversion of the same amount of one form of spatial velocity to another.
10. Thus, the entire fabric of the universe is a single field of greater or lesser intrinsic spatial velocity = mass-energy within a universal field of c velocity.
11. In CTOE, space isn't curved by the presence of mass-energy, it's flat with fields of intrinsic spatial velocity densification that produce the same mathematical results as curved relativistic space.
12. Within this universal spacetime field particles have actualized. The existence of particles and particulate matter enables movement relative to the spacetime fabric, and thus to each other. This profound but simple fact is what enables events to occur, observations, and ultimately for conscious human life to exist. Its subtle but profound importance can't be overemphasized.

13. Particles are essentially little ‘crystals’ of spacetime that have actualized out of the spacetime fabric to be able to move and interact relative to it.
14. Individual particles too have constant spacetime velocities equal to c, and in addition exhibit a number of individual particle properties that govern their natures and interactions.

THE ‘ABSOLUTE’ BACKGROUND

1. The universal spacetime fabric is the aggregate dimensional aspects of all particle interactions. It’s the grand scale dimensional aspects of the entanglement network described in the previous section.
2. This logico-mathematical structure is the ‘background’ with respect to which all further particle interactions take place. It’s the background that rotation is relative to as in the problem of ‘Newton’s bucket’. It’s also the original inertial path with respect to which actual spatial velocity and actual time dilation is with respect to. It’s what Planck sought when he spoke of the ‘average mass of the universe’.
3. In essence the spacetime fabric is a quasi-absolute dimensional spacetime background that isn’t intrinsic, but rather emergent from the dimensional aspects of the aggregate of all particle interactions.

BLACK HOLES

1. If the CTOE model of the spacetime fabric is correct then there is a maximum possible mass-energy density which produces a maximum possible intrinsic spatial velocity in which all the c spacetime velocity is in the form of intrinsic spatial velocity and as a result velocity through time becomes zero.
2. This gives us a completely new understanding of black holes. In this model, the fabric of spacetime can’t be infinitely curved or compressible. Black holes are uniform spheres of spacetime fabric with maximum possible intrinsic spatial densification due to the maximum possible packing of mass.
3. So, there is no longer any spatial curvature that continues into the hole converging to a singularity where ‘the laws of physics break down’. Again, contradictions are impossible in a computational universe computed by consistent rules of logic.
4. This model may be testable if the actual diameter of black holes becomes directly measurable as it should predict different diameter-mass ratios than the current infinitely curved space model. If confirmed this would also confirm related aspects of CTOE.
5. In the view of stationary external observers in empty space, objects falling into a black hole appear to slow down and stop at the event horizon. This is because outgoing light takes longer and longer to overcome the increasing gravitation nearer the horizon. As a result, some mistakenly claim infalling objects ‘pile up’ on the event horizon. But, since the *rate* of outgoing photons slows to zero at the horizon and their wavelengths are

stretched, objects simply appear redder and redder and fade away. This is why photos of our black hole (actually its spiraling accretion disk) are red shifted.

6. Actually, infalling objects just continue to fall faster and faster until they reach the event horizon. However, thanks to the standard equation of addition of relativistic velocities, $v = (v_1 + v_2) / (1 + (v_1 \times v_2)/c^2)$, their combined linear and vibrational velocity never exceeds c.
7. A hypothetical observer falling into a black hole would experience two opposing effects. First due to the increasing relative velocity of external objects their clock time appears to slow towards zero. But on the other hand, the time rate of infalling observers is actually slowing. Within black holes time stops so observations are no longer possible.
8. Thus, black holes are *uniformly dense spheres* of maximal c spatial velocity and zero temporal velocity rather than the current view as spheres of increasing density from the event horizon to an infinitely dense central singularity where the laws of physics 'break down'. There are no such singularities, and certainly no portals or wormholes into other spacetime locations or universes.

COSMIC GEOMETRY

1. The dimensional spacetime universe that emerges from particle interactions in aggregate, takes the form of the *surface of a 4D hypersphere*. This is the cosmic geometry of the universe. This surface is the entire 3 dimensions of space in the current universal present moment common to the entire observable universe. Its positive inward curvature results from the mass-energy content of the universe.
2. The radial dimension is present moment time, not clock time which varies widely across the surface depending on local spatial velocity. Implicitly, the radial present moment time dimension extends back to the point of the big bang at the center of the hypersphere, but only the current universal present moment time surface actually exists.
3. So, the surface is the current universal present moment of the 3 dimensions of space, and the radial dimension is the no longer extant history of the past universal present moments of the universe extending back to the big bang. The 3-dimensional analogue would be the surface of a balloon being blown up over time.
4. The other geometric possibilities of the universe having edges or being infinite are as illogical as the surface of the Earth having edges. And anything actual being infinite is a logical contradiction. Infinity isn't a static number, it's the impossible end point of a never-ending process of continual addition. Anyone who claims the universe, or anything else, is 'infinite' simply doesn't understand what they are talking about.
5. However, it is possible that the universe could be infinite in the sense of existing forever, of existence itself having no beginning and no end through a never-ending cycle of big bounces as we will soon see.
6. Thus, even though the curvature of the universe is very nearly flat, it cannot actually be flat or it would have edges. The universe's curvature seems flat because it's enormously large, just like a local measurement of the curvature of the surface of the Earth appears flat because Earth is relatively much larger than the measuring apparatus.

7. So, the usually illustrated expanding tube 3-dimensional approximation of the geometry of the universe should be replaced with an expanding sphere instead.
8. The universe is currently expanding but even if it were contracting the radius would be the progression of present moment surfaces, not whether it was contracting or expanding.
9. Everything on the present moment surface continually advances through spacetime at the speed of light in vacuum, c, as the surface continually advances in present moment time.
10. Objects with relative spatial velocities within the surface see each other's clocks running slower, while objects with actual spatial velocities relative to their own original inertial paths due to actual tangible accelerations have actual slowing of their clock time relative to their original inertial paths. Thus, the total spacetime velocity of everything within the surface always remains equal to c for all observers of all things including themselves.
11. This c spacetime velocity of the universal surface and everything in it is precisely the continual expansion of the universal surface itself at the speed of light in present moment time. To the extent there is no spatial velocity within the surface there is a cosmic universal clock time that progresses as a function of present moment time. To the extent there is spatial velocity local clock time progresses at a slower rate within present moment time.
12. Spacetime velocity entirely in time is staying at the same place in space while continually riding the speed of light expansion of the surface of the universe.
13. This continual c present moment time expansion of the universal surface is not the same as the Hubble expansion which is an expansion in cosmic clock time rather than present moment time.
14. Since dimensional spacetime emerges computationally from the current state of the entanglement network, and isn't a physical structure, one should use caution imagining this geometry evolving as a physical structure. In particular equating the expansion of the universal hypersphere due to extension of the present moment time surface with the Hubble expansion, or a possible contraction thereof.

TIME TRAVEL & SPACE TRAVEL

1. The geometry of the universe determines what types of time and space travel are actually possible. The only real actual extant current present moment of the universe is its current 3-dimensional surface. Only this universal current present moment exists.
2. Everything that exists, the entire universe, exists only in the current universal present moment common to the entire universe. The past is gone forever and no longer exists, and the future has not yet been computed by the universal processor that computes the common current present moment.
3. Thus, time travel to an actual past or actual future is impossible since neither exists. Thus, it's impossible to go back to the past and view dinosaurs, or to go back and kill your mom before you were born. Neither an actual past or future exists. It's impossible for a computational universe to compute contradictions.
4. However, we, and everything that exists, do continually 'travel' through combined spacetime at c, the speed of light in a vacuum, as the universal processor continually computes the evolution of the observable universe. The only type of 'time travel' possible

is to travel at different velocities through clock time within the universal present moment. This is possible since actual spatial velocity slows the passage of clock time.

5. Everything continually exists only in the current common present moment and the only sense time travel is possible is for local clock time to pass at different rates in the common universal present moment due to differences in spatial velocity.
6. Thus, an ancient Greek could theoretically embark on a relativistic space trip 2500 yrs. ago and return to Earth today not a lot older than when he left bringing with him videos and brand-new items from the past. But once here, there's no way to return because ancient Greece no longer exists.
7. And likewise, we could embark on a relativistic space trip today and return to Earth at a time in the future of our choosing. But once there, there isn't any way to return to the Earth that we left which would no longer exist.
8. In either case we'd both continually stay only in the current universal present moment as it progressed but with different clock time rates depending on our spatial velocities. The 'far distant future' we arrived in would then be that current universal present moment.
9. In both cases the traveler always remains in the current universal present moment, his clock time just passes a lot slower due to his relativistic spatial velocity.
10. Likewise, the slowing of clock time with spatial velocity theoretically enables one to travel to the galactic center and even far across the universe within a human lifetime traveling at just a constant acceleration of G, equal to the Earth's gravitational force. The resulting spatial velocity approaching c would reduce the traveler's velocity through time to almost zero.

OUR SPACETIME SINGULARITY

1. The 4-dimensional geometry of the universe can be visually confirmed. Everywhere we look we see the 3 dimensions of space extending linearly in every direction, and we see the single dimension of time as distance in every direction from every point in space. This 3-dimensional slice of the 4-dimensional history of the universe is called our *light cone*. It is where light from everywhere in the universe reaches us in the present moment.
2. Because everything we see is light from past events at some distance no matter how slight, those events no longer exist when we see them. The only actually existing part of our view of the universe is the single point in which we exist, though thankfully, the high velocity of light makes it appear that events whose light distance is less than our perceptual resolution share our present moment.
3. Thus, everything that exists, exists within the current present moment surface of the universal hypersphere, and everything that exists, exists within the spacetime singularity of the point of its own existence, and the actual current present moment of everything else in the universe is unknowable until light from its past reaches us.
4. Though we cannot visually confirm it, everything that exists, exists within the surface geometry in a common current universal present moment. Other than this universal present moment across the universal surface there is not even nothing.
5. Time flows out into the past in every direction through every point in the universe. And time flows into the present moment at every point from nonexistence. Our view of the

universe is analogous to the view from the back of a train in every direction speeding into a nonexistent future in no direction. We see the past as distance in its light in the present moment at our spacetime singularity, but it's impossible to see into the future as it doesn't yet exist and has never existed.

6. Currently the universe is expanding very slowly, presumably uniformly in all directions. This means that an observer at any point can only see a spherical volume of space around 16 billion light years in radius. Beyond that 'particle horizon' the cumulative relative expansion is greater than the speed of light, so light from beyond it can never reach an observer at its center. The sphere enclosed by a particle horizon is very much smaller than the volume of the actual universe.

THE BIG BANG & COSMIC INFLATION

1. The origin of cosmic geometry was the big bang in which vast numbers of new high energy particle precursors actualized within the universe due to an infusion of enormous energy in the form of spatial velocity. Large amounts of energy produce scores to hundreds of new particles whose particle properties individually sum to zero. This routinely occurs in highly energetic collisions at the LHC and other colliders.
2. Prior to the big bang present moment time would have existed since that's necessary to compute the big bang, but not yet dimensional clock time or space, which are emergent from particle interactions.
3. If, as CTOE posits, dimensional spacetime is created by dimensional relationships formed by particle interactions, the big bang instantly produced the vast expansion of new dimensional space necessary to contain the new particles and their interactions. This expansion began to slow the relative velocity of the precursors (relative velocity being kinetic energy which is heat). This reduced average universal temperature so particle precursors would have low enough energies to combine to form particles.
4. This initial vast expansion of space is called *cosmic inflation*. In cosmic inflation the universe is thought to have undergone an enormous expansion from an infinitesimal dimensionless point by a factor of at least 10^{78} in a minute fraction of a second, as space expanded far faster than the speed of light.
5. However, there's a much simpler explanation. If we merely assume everything in the universe was expanding away from each other at *very nearly* the speed of light just from the momentum of the big bang itself, this universal spatial velocity would produce an immense slowing of cosmic clock time throughout the entire nascent universe to almost zero.
6. Thus, we have a consistent expansion model simply from the conversion of spatial velocity initially to electrons, quark-gluon plasmas and photons traveling at the speed of light, and then very slightly sub-luminal spatial velocities as elementary particles and atoms begin to form. With the decrease in average spatial velocity the cosmic clock time rate would begin to increase from near zero to more recognizable current rates.
7. Thus, inflation would take place in almost no clock time, even though present moment time was proceeding to compute the universe at the same rate it does now. This solves the problem of cosmic inflation without the need for a hypothetical 'inflaton' field for which

there is no independent evidence and was invented just to make the current model of inflation work.

8. This results in a much simpler model in which a continuous cycle of cosmic expansions and big bounces is due only to the initial mass-energy of the big bang and a resulting increase in gravitation produced by increasing dark matter as will be explained shortly.
9. The simplest and most obvious model of the expansion of the universe is that the expansion begins with the big bang and cosmic inflation and has continued slowing to this day under their original momentum under the influence of its increasing mass-energy content. Without solid evidence to the contrary this model should be assumed first.
10. Thus, post inflation, the expansion of the universe in cosmic clock time has slowed under its original momentum and the gravitational contraction of its mass-energy content to the very slow current Hubble rate. This locally very slight average spatial velocity results in a current cosmic clock time rate with essentially zero universal time dilation. (Dark energy accelerated expansion will be discussed below.)
11. Since the radial dimension of the universe is present moment time, not clock time, this new CTOE model means that the radius and size of the universe would be enormously greater than currently assumed. And this would explain why the curvature of the universe is measured as almost flat. The surface of an extremely large sphere appears flat even though it's actually curved.
12. There was no initial dimensionality, no grid, orientation, rotationality. but once dimensionality began to emerge the dimensionality that followed tended to align with it because was computed relative to it. Just as a seed crystal may orient arbitrarily initially, but then tends to grow along that initial orientation.

THE ORIGINAL INERTIAL PATH

1. In the previous section on *Fundamentals*, we saw that actual time dilation, as opposed to observational time dilation, is due to actual spatial velocity with respect to an original inertial path. As John Baez of Caltech says, "Time dilation is due to deviation from an (original) inertial path." We are now in a position to identify what that original inertial path is.
2. As the average relative velocity of inflation slowed, the reduction in the kinetic energy of spatial velocity reduced sufficiently to allow particle precursors to combine to form a plasma composed of charged particles. Charged particles strongly interact with light resulting in the 'dark ages period' of the early universe.
3. Then around 380 million years after the big bang, the avg spatial velocity kinetic energy reduced enough to allow the original charged particles to form atoms primarily of hydrogen. At this 'first light period' light began to move freely through the universe.
4. Original light from this period still exists and is detectable today in the form of the CMB, or cosmic microwave background. It exists now in the form of microwaves since its wavelengths have been stretched by the expansion of space since it was originally emitted.
5. The CMB gives us a look at the first visible structure of the information of the dimensional universe created by particle interactions during the big bang and inflation. It

is the emergence or coalescence of dimensionality from the aggregate of initial particle interactions. And, importantly it is thus the emergent dimensionality with respect to which all further particle interactions take place with respect to.

6. Thus, the CMB should be the original inertial path that current actual spatial velocity and actual time dilation are relative to. The average spatial velocity of the CMB left over from the big bang is very likely the universal original inertial path of all subsequent relative motion. If so, it is spatial velocity relative to this original inertial path that produces actual time dilation.
7. Now, the solar system moves relative to the CMB at 368 ± 2 km/s, so Earth is moving relative to its original inertial path at approximately this velocity. Because it has this actual spatial velocity with respect to its original inertial path clock time on Earth should be running measurably slower than on a clock stationary with respect to the CMB.
8. If this is true is there a way to confirm it by measurement? The obvious way is to simply accelerate a clock until it's stationary with respect to the CMB and compare its rate with clocks on Earth. But that doesn't work because both clocks would see the other running slower by the same rate due to their relative motion. Hopefully there may be some way to get around this, but there is another approach.
9. The time distance to the CMB measured from Earth is 13.8 billion years. But if time was ticking faster on a clock which had never deviated from its shared spatial velocity with the CMB, the time distance measured from that clock to the CMB should be appreciably greater. The CMB should appear to be significantly older than 13.8 billion years. This is also true of the time distances to other 'standard candles'.
10. The way to test it is by giving a CMB age measuring device an acceleration to sync with the spatial velocity of the CMB. If the original inertial path theory is correct that should return it to its original inertial path where clocks are running faster. Thus, its measurement of the time distance to the CMB and other standard candles should be greater.
11. The CMB is the original dimensional information structure that emerges from particle interactions in the big bang and inflation. Thus, it's the dimensional structure that all subsequent particle interactions are computed relative to. It is the quasi-absolute background with respect to which actual spatial velocity is relative to. It is also what rotation is relative to as in the problem of Newton's bucket. The CMB is what Planck was searching for in his postulated 'average mass of the universe'.
12. We can prove the original inertial path is universal because assuming it isn't leads to a contradiction. Assume 2 frames in relative motion, but each with zero spatial velocity relative to a different original inertial path. Now assume they meet. To meet one or both must change its velocity, and thus now must have some spatial velocity relative to its original inertial path.
13. But now they are on the same spacetime path described by a single frame, and so must have identical space and time velocities. But the one that still has spatial velocity relative to its original inertial path should be experiencing time dilation, while the other isn't. This means, their clocks should be ticking at different rates.
14. So, either there is a universal original inertial path common to all clocks or the original inertial path theory is wrong. In my view, the evidence for a universal original inertial path is overwhelming, but only time will tell.

THE DARK MATTER EFFECT

1. The *dark matter effect* is an additional gravitational force originally necessary to account for the observed increased velocity of stars around the edges of galaxies. Additional evidence of galactic motions and gravitational lensing now show that dark matter is very common in many areas of the universe. This is confirmed by the recently discovered dark matter concentrations around black holes.
2. Currently it's assumed that dark matter is caused by yet undiscovered 'dark' particles outside those in the standard model that only interact through the gravitational force. But there is a much simpler possibility that doesn't require any new hypothetical particles.
3. The observable universe is expanding, but unevenly. According to Misner and Thorne, completely empty space expands uniformly, but the space within galaxies is gravitationally bound and doesn't expand.
4. This results in an uneven expansion of spacetime around galactic boundaries; precisely where dark matter is needed to account for observed stellar rotation rates.
5. Now, it's well known that gravitational fields are spatial curvatures. Thus, spacetime distortions produced by uneven spatial expansion should be producing gravitational effects. If these effects aren't dark matter, then where and what are they?
6. Thus, the spacetime distortions produced by the uneven expansion of spacetime may actually be dark matter.
7. This theory has several advantages. It neatly explains the dark matter effect exactly where it's needed. It's also automatically dark, and not directly observable by its very nature, and it doesn't require any new hypothetical particles outside the standard model. If spacetime is a distortable fabric that can be curved by the presence of mass-energy, then if should also distort under its uneven expansion.
8. Once such distortions are created, they should move just as gravitational masses do under mutual gravitational attraction. This results in the observed distribution of dark matter not just around galactic boundaries. This theory can be tested by running backward simulations of dark matter concentrations to see if they do originate around galactic boundaries.

DARK ENERGY

1. Since 1998 measurements have suggested the expansion of the universe has been slowly accelerating over the past ~5 billion years due to an effect called *dark energy*. The simplest theory of dark energy is called *vacuum energy*. The quantum vacuum continually emits and reabsorbs particle-antiparticle pairs and this produces measurable intrinsic energy that expands space. And, as new space is created by the expansion that too contains this same expansive energy. Thus, the resulting expansion of space slowly accelerates as its expansion creates new space and more vacuum energy.

2. There are other theories of dark energy, including some that propose it's actually caused by measurement anomalies. Another simple possible explanation is a very slight increase in the relative rates of present moment time ticks. This could cause a very slight increase in the underlying cosmic time rate that would give the appearance of increasing expansion, though it's not clear what other effects that might produce.
3. One possible cause of dark energy's apparent increase in the expansion rate could merely be an effect of an increasing amount of dark matter. If the amount of dark matter increases over time, nearer newer areas will have denser dark matter. Thus, light should be gravitationally redshifted more in nearer newer space than older more distant space. This could be mistaken for nearer newer space expanding faster. Thus, whether dark energy exists or not may be in question, but even if it does it could eventually lose out to dark matter.

UNIVERSAL COLLAPSE

1. If dark matter is due to uneven cosmic expansion, it should increase exponentially over the life of the universe. Once formed, its increased gravitation results in ever increasing spacetime distortion as the universe continues to unevenly expand around it. Currently there is thought to be more than 5x as much dark matter as visible baryonic matter
2. Though current evidence suggests dark energy is overcoming the dark matter effect, I suspect that the apparent accelerating expansion of dark energy is actually a measurement anomaly produced by increasing dark matter as explained in the previous paragraph.
3. If this is correct, the slow *exponential increase* in gravitational mass-energy due to an accelerating dark matter effect will eventually overcome any actual accelerated expansion. This will eventually result in sufficient gravitation in the universe to slow and stop its expansion, and begin an accelerating collapse into a universal black hole.
4. Once the turnaround begins the universe collapses much faster than it expanded. The contraction in turn produces exponentially increasing additional spacetime distortions and gravitation as spacetime crumples under its collapse.
5. As a result, the entire universe should collapse relatively quickly into a single universal black hole containing all the mass-energy of the universe. And since it's particle interactions that emergently create dimensional spacetime, and there are no more particle interactions outside the universal black hole, spacetime itself will also collapse into the universal black hole. Outside the hole itself not even nothing will remain.
6. At this point, the only dimensional spacetime remaining would be due to particle interactions occurring within the hole itself. However, the universal processor continues to compute the universe within the hole in present moment time which never stops.

A BIG BOUNCE UNIVERSE?

1. Within the universal black hole, matter is maximally compressed first into neutrons as in neutron stars and then into a quark gluon plasma. Most of the particulate mass of the

universe consists of protons and neutrons. These are composed of more elemental particles called quarks, but it's known that the mass of these quarks amounts to only around 5% of the masses of the protons and neutrons they compose. Roughly 95% of quark mass is pure energy in the form of vibrational spatial velocity.

2. Since the mass of quarks is 95% spatial velocity and there is no more external spacetime to confine it, the entire mass of the universe is instantaneously converted into an unimaginably enormous burst of kinetic energy in the form of spatial velocity within the universal black hole.
3. This is precisely what the big bang was, an injection of enormous energy in the form of kinetic energy spatial velocity into the universe that resulted in a big bang, cosmic inflation, and an expanding universe.
4. So, at this point a new big bang-inflation occurs. An entirely new observable universe begins inflating from the near instantaneous conversion of all the mass in the universe to kinetic energy in the form of spatial velocity.
5. If this model is correct, it predicts a cyclical universe with *continuous big bounces*, where successive big bangs produce expanding universes that accumulate increasing dark matter effect gravitation over time until this causes them to collapse into universal black holes, which then convert the mass of the universe into expansive energy and repeats the process over and over again.
6. The simplest model is to imagine the observable universe expanding uniformly from the momentum of the big bang produced by the instantaneous conversion of the mass of a universal black hole to near speed of light spatial velocity. This is the conversion of the total intrinsic vibrational spatial velocity of the black hole to the linear spatial velocity of radiation traveling at c.
7. Thus, a sequence of big bounces presumably continues forever. Whether a big bounce could possibly tweak the complete fine-tuning is an interesting unanswered question.
8. Note that this big bounce model is also compatible with various observed early universe structures that seem too large to have had time to form. If the big bang was a conversion of all the matter of a previous universe, and the black hole it emerged from wasn't completely uniform but lumpy one would expect some large-scale relic leftovers to seed such large-scale structures.

BLACK HOLE QUANTUM EFFECTS

1. Black holes aren't perfect. First matter can attain spatial velocities arbitrarily close to c, but can never actually reach c. So, the velocity of time within black holes arbitrarily slows towards zero, but never completely comes to a stop.
2. In addition, quantum effects continually produce statistical randomness at the particle scale within black holes, as they do in all processes.
3. These statistical inhomogeneities may well provide the triggers that initiate the transition from universal black holes to new big bangs.

ENTROPY

1. Entropy is the tendency for an isolated system to reach a final equilibrium over time. For example, an enclosed gas with regions at different temperatures will soon reach the same average temperature throughout in the absence of any inputs to or outputs from the system. This is the state of *maximum entropy* of the system. Entropy is a consequence of the 2nd law of thermodynamics.
2. When applied to the universe as an isolated system, scientists seem to think of entropy as a semi-mystical power that is the source of time's arrow, and the cause of the end of the universe eventually causing it to 'run down' and reach a universal equilibrium in which nothing further happens. And Penrose and others see a fundamental problem in how the universe could obtain a putative initial *minimum* entropy state at the big bang that would enable it to have the initial entropy necessary to run out its lifetime until an ultimate demise in a state of maximum entropy.
3. But entropy isn't fundamental, as assumed. It actually depends on the distribution of forces, which are fundamental. For example, in a continually expanding universe controlled by a dark energy like repulsive force, the maximum entropy state would be an enormously large almost empty space with even distribution of any material able to withstand the repulsion and remain intact. On the other hand, in a collapsing universe where attractive gravitation rules, the maximum entropy state is just the opposite, a universal black hole.
4. So, entropy isn't fundamental, it depends entirely on the distribution of prevailing forces, which are fundamental.
5. Thus, in CTOE, the universal black hole is the maximum entropy state of a universe collapsing under increasing gravitation, and the near instantaneous conversion of the entire mass of the universe into kinetic energy instantly resets this maximum entropy state to the minimal entropy state of the newly born universe. The switch in forces from attractive to repulsive instantly changes the entropy state from maximum to minimum. This is the solution to Penrose's problem.
6. Likewise, entropy has nothing to do with the arrow of time since entropy varies widely across the universe, with no correlation at all to clock time or its direction. The *arrow of time is the sequence of current universal present moments computed by the universal processor.*

INFORMATION COSMOLOGY

1. Everything in the universe is fundamentally the information that it is. So, to properly understand the universe we need to understand its information cosmology, to look at the entire universe as the information it contains, how it's computed, and its resulting information structures.
2. Herein 'information' and 'data' are used interchangeably. Technically 'information' refers to *meaningful* data, but all data is meaningful to the processes in which it's involved.

3. The amount of information in the observable universe is the number of bits it contains. Since new particles can actualize and particle-antiparticle pairs can annihilate, the amount of information is not fixed. Information is not conserved overall but may be in particular processes.
4. Some mistakenly confuse information with meaningfulness to humans, that a million bits of Shakespeare contains more information than a million 'ones'. This is incorrect and leads to false cosmological speculations. The millions 'ones' contains all the exact information of what it is just as the million bits of Shakespeare does.
5. Thus, the observable universe is an enormous network of continually evolving information of which only its state in the current present moment actually exists.
6. The entire history of the observable universe is a process in which the current information state of the entire universe is simultaneously computed from its prior information state in every tick of present moment time. Each of these computations involves random quantum processes but computes exact results in the form of exact dimensional fragments that are intrinsically random with respect to each other.
7. Thus, the entire past information history of the universe is completely exact in every last detail. Once computed it cannot be changed, it's completely fixed down to the finest detail.
8. In contrast the present moment is computed stochastically, with its quantum scale information computed according to somewhat random processes. These quantum scale processes manifest in the classical world as its seeming randomness, all of which is actually the emergent effects of quantum randomness.
9. This means that the future is not predetermined. There is no 'block universe' or 'block time'. How could a predetermined universe with a logical causal structure be somehow created all at once in the absence of the computational causality it embodies?
10. Thus, the original complete fine-tuning of our universe is also completely fixed and unchangeable. It's the only possible complete fine-tuning possible in our universe. The notion that the universe could have possibly had alternate complete fine-tunings is impossible.
11. In addition, it could well be possible that our complete fine-tuning is the only one possible at all. It's certainly true that its logical structure appears to be the only one consistent and rich enough to create a universe. The particular values of the elemental constants is less certain, but could also turn out to be the only ones possible somehow. In any case, the notion there must be a vast number of other universes, each with one and only one of the other conceivable sets of fundamental constants is wildly unwarranted. All evidence suggests ours is the only existing universe, and there is zero possibility ours could have had any other complete fine-tuning.
12. Thus the 'anthropic principle' speculation, that the universe is tuned to allow intelligent life to exist because we are here observing it is pretty much a truism. It's certainly possible to *imagine* other complete fine-tunings, but completely impossible they could have possibly existed in our universe, and highly unlikely there are any other universes at all with any complete fine-tunings, ours or otherwise.

EVERYTHING IS ITS COMPLETE COMPUTATIONAL HISTORY

1. We have seen in the section on *Fundamentals*, that everything that exists is the complete exact information of what it is down to the exact information of every one of its particles and particle properties and how they are all functioning as part of an interconnected whole in the current universal present moment.
2. The continual recomputation of the data state of the observable universe creates an implicit information structure, stretching back to the big bang and original complete fine-tuning, that is completely exact, unalterable, and entirely logically consistent and logically complete. This is the complete information history of the observable universe. This information history isn't a separate extant structure. It exists only in the resulting current values of all extant particles and particle properties. In this way the information of past things and events does still exist in a redistributed form in the current information states of things resulting from those past interactions.
3. Thus, much of the past information history of things is deducible from the present information states of things. But as the past no longer exists and its information isn't explicitly encoded, many details are forever lost.
4. So, everything that exists *is* the complete current information of itself, and this is the current result of the complete computational history of it and all its precursors since the big bang and original complete fine-tuning.
5. Thus, the current information of things contains abundant information about past interactions, and the information of other things, both past and present. Thus, the information of other things and events is deducible from the collective information of things. This is the *Sherlock Holmes Principle* which underlies all science and knowledge.
6. When things interact with other things, the changes to the information those things are is the computational result of the information of the things they interact with. Thus, the continuous computational interactions of things continually redistributes the information of the interacting things through the universal information network. In this way, the information of all things continually flows through the universal information network.
7. Thus, the information that anything is contains traces of all the other things it has interacted with throughout its computational history. Thus, everything that exists is the current computational result of its complete interaction history throughout its existence and the existence of all its precursors all the way back to the big bang.
8. Everything that exists is the complete exact information of its entire computational history of interactions with other things all the way back through all its precursors to the big bang and complete fine-tuning – *and that is all it is*.
9. Properly understood, these are profound and amazing insights that radially transform our view of the universe and everything in it.
10. Thus, *everything that exists, without exception, no matter how humble or ordinary, is a secret window onto the entire history and information structure of the universe.*

THE LEAF ON THE LAWN

1. For example, this leaf on the lawn is the complete exact information of the complete exact current computational result of an enormous complexity of information over its life span and far beyond, and much of that information can be deduced from the current information that everything is.
2. The general form of the leaf is the result of the complete evolution of its species over millions of years through countless other species back to the origin of life.
3. The exact form of this leaf is the result of a complex mix of its exposure to light and supply of nutrients from the branches and twigs of its tree, and its lifetime of individual exposures to insects and microorganisms.
4. This depends on the exact enormously unlikely statistical coincidence of the pollen transfer and which particular grain of pollen produced fertilized the exact pistil that resulted in the exact DNA that grew the particular tree that produced the leaf.
5. And this is turn depended on the leaf's ancestor tree producing the particular seed and its transport to the particular location in which that seed took root, and to this process repeating through thousands if not millions of years in every one of its ancestors.
6. This is a function of the location of the tree relative to geography and other trees which depended on the breezes or organisms that deposited the seed from which the tree sprouted, and in turn all the enormous complexity and chance that resulted in that deposit of the seed in that particular location, and the chance details of every preceding tree and life form in its ancestry. If every one of these countless billions of details did not occur exactly as it did, that leaf would not lie on the lawn as it does. Thus, the exact information of the way it does lie on the lawn is a window onto all the computational events that resulting in the way it currently lies.
7. The exact current condition of the leaf on the lawn is also determined by the exact aerodynamics of its form, the change of seasons determined by the geographical location of the tree and the variations of weather each in turn determined by their complete information history dating back to the formation of the planet and its location relative to the sun, and the local effects of vagaries of its atmospheric and water cycles and so forth.
8. And finally, the leaf's current location on the lawn is determined by the exact set and sequence of breezes which brought it to its current location, and the microorganisms and moisture and temperature currently affecting it; each again the exact current computational result of their own incredibly complex information histories back to the beginning of time.
9. And this is only the briefest of summaries. In reality there is much much more, not only for this particular leaf but for every one of the trillions and trillions of leaves across the planet, and for every one of the ginormous unfathomable number of individual things on this planet and throughout the entire universe. Every one is the information of the exact result of all its multitude of interactions throughout the entire history of the universe.
10. Thus, everything that exists, without exception, no matter how humble or ordinary, everything around you right now and at every moment of your life, including even yourself, is a secret window onto the entire history and information structure of the universe, much of which can be glimpsed in the complete current information of everything that exists. Everything is the complete information of what it is, and that is a combination of redistributed fragments of information of enormous numbers of other things. Everything that exists is its complete exact information in the current universal

present moment, and that is entirely a combination of the information of other things. And that's all anything is, and all everything is, including even ourselves.

THE SHERLOCK HOLMES PRINCIPLE

1. Because everything that exists contains information about what created it and what it's interacted with, one can gain knowledge of those other things from the current information of things with shared interaction histories.
2. Theoretically one can piece together the complete information of anything or any event from the information contained in all other things that interacted with it. This is the *Sherlock Holmes principle* which is the basis of all knowledge, science, and forensics. It's an extremely important fundamental principle.
3. Thus, the universe is rich with the detailed information of its complete history redistributed through the information of its current state.
4. The current information state of the universe is a vast redistribution of the information of all the things, processes, and events in the history of the universe in the current information of other things.

OBSERVERS & EXPERIENCE

1. This is also the fundamental principle of observation. Human and other biological observers are simply an extension of the basic phenomenon that interactions of things transfer information about those things. Through adaptive evolution, more complex biological observers have developed specialized internal systems that are modified to encode selective information about the things they interact with. In this way observers construct information models of themselves and the world around them.
2. So, the notion of observers is a fundamental aspect of information cosmology. In essence the universe can be said to evolve intelligent observers in order to know itself, and conscious observers to become conscious of itself. All this is based on the fundamental fact that interactions exchange information about each other when they interact, and things exchange information of themselves with the other things they interact with.
3. *Thus, the concept of observer is built into the structure of the universe.*
4. Likewise, *the concept of observer experience is inherent to the information structure of the universe*. The mutual exchange of information in every interaction of things is essentially things experiencing each other. So, the concept of experience is a fundamental aspect of the universe. The experiences of complex biological observers are evolutionary developments that build on this fundamental principle.

THE GENERAL PRINCIPLE OF EVOLUTION

1. Things are their information structures, and their information structures evolve via their interactions with other information structures, with their interactions with their *information structure environment*.
2. Thus, information structures evolve, survive or die out depending on the particulars of their interactions with their information environment. Those that tend to survive can be said to be better adapted to their information environment, and the population of these structures tends to increase within similar information environments.
3. So Darwinian evolution is just a special case of this general principle that applies to biological information structures able to reproduce their kind. Those that survive, often mainly by chance, and to a lesser degree by being better adapted to their information environment, are more likely to pass on their information characteristics, including those that facilitated their survival. In this way, those adaptations tend to increase within the population, and populations with those adaptations tend to increase.
4. So Darwinian evolution is a biological manifestation of the basic principle that in our universe information forms influence the evolution of the information environments they interact with.

III: EMERGENCE & LIFE

EMERGENCE

1. Everything above the most elemental is emergent. Emergence is the tendency at all scales for more elemental structures to aggregate to produce more and more complex structures rather than just uniform homogeneous repetitions of themselves.
2. Elementary particles aggregate to produce atoms. Atoms aggregate to produce molecules. Molecules aggregate to produce chemical materials and structures. Some chemicals aggregate to produce DNA and living cells. Living cells aggregate to produce organisms. organisms in aggregate produce cultures and civilizations. Cultures and civilizations in aggregate produce the great sweeps of history over time. Material structures in aggregate form all the structures of the observable universe.
3. Emergence is both continuous over evolutionary time and operational in the moment. Examples of operational emergence are the collective operation of individual neurons to produce a mind, and the aggregate self-organized molecules in a fox to produce the fox.
4. In our universe emergence is enormously rich with the production of immensely complex multiple hierarchies and networks of vastly varied structures at all scales. This is due to the incredible richness of our complete fine-tuning which includes the rules by which emergence is computed. In particular these rules include the values and combination rules of particle properties and the strengths and balances of the three primary forces responsible for the details of emergence
5. Emergence includes both emergent structures and the emergent rules that describe the behaviors of those structures. Almost all of what we call science refers to the laws of more complex structure that emerge along with the structures they describe. A simple example is the laws of gases which describe rather than actually computing how gas molecules behave in aggregate under various conditions.
6. Emergence is so incredibly rich, that given time and circumstance, the universal computer produces discrete individual structures that themselves act as programs, as computational structures. In this is the origin of autonomous life forms which are subprograms or subroutines of the universe that have evolved to act intentionally and quasi independently to further their own survival.
7. DNA encodes developments in the information of living programs and thus disseminates it widely. Just as writing, printing and the internet allows human knowledge to be preserved and spread, so DNA encodes the software of life so it doesn't have to be reinvented over and over through thousands or millions of years.
8. DNA is software that encodes the information to create, build, maintain, operate and reproduce biological beings. The continual expression of the trillions of copies of our DNA software is what makes us who we are and what we do.
9. This section on *Emergence & Life* covers the basic structures of the emergent universe and how they lead to the concomitant evolution of information. The hidden key to emergence is the continuing evolution of the information *of* things to include information *about* things, and the emergence of integrated bottom-up and top-down computational programs.

ACTIVE INTELLIGENT DESIGN

1. The laws of the complete fine-tuning are continually used to compute every particle interaction in the observable universe, and ultimately every aspect of emergence. These laws are such that they have led to the evolution of conscious intelligence in our universe, and thus must implicitly encode for the possibility of intelligence and consciousness.
2. The enormously profound intelligent design of the universe is not evidence of an intelligent designer God, but rather that the design of the universe itself is inherently implicitly intelligent. The design of the complete fine-tuning leads to the evolution of intelligence, and thus must implicitly contain it. Thus, the computational process continually creating everything in the universe is continually creating a living universe with intelligence and consciousness.
3. These elemental computations continually create a living intelligent universe in the same sense that the function of the individual neurons of our minds are organized to continually compute our thoughts and actions. The elemental computations of the universe continually self-organize to create our universe of intelligence and consciousness. Knowing this most profound secret of the here-now universe we know with certainty that at the most fundamental level in the most profound sense everything is right with the universe, here now and forever, long after we dissolve back into it. Thus, if anything is to be considered divine, it's the active intelligent design of the universe itself.
4. Thus, the computational universe itself must be considered a virtually intelligent and virtually conscious living organism that continually computes its own evolution towards an explicitly intelligent and explicitly conscious living system, able to become conscious of itself and intelligent about itself through the conscious living organisms it evolves.
5. Intelligent conscious living organisms such as ourselves, are in effect the conscious intelligent sense organs of the universe through which it is able to sense and know and become conscious of itself.
6. So we, and other living organisms, are the emergent intelligent sense organs of the universe it has evolved to become conscious of itself. We are the unconscious universe becoming conscious of itself.
7. Thus, everything that happens in the universe without exception, every computation of every particle interaction is the unconscious action of a vast omniscient intelligent design whose aggregate actions at the aggregate scale manifest our intelligence and our consciousness of the most profound and awesome secret of the universe.

THE MATERIAL UNIVERSE

1. The visible universe is primarily composed of ordinary or *baryonic matter* which consists of emergent aggregates of the elementary particles. Baryonic matter consists of atoms

and atoms bound in molecules and other forms of matter. Atoms are generally electrically neutral structures composed of positively charged protons and neutral neutrons in a nucleus, and roughly equal numbers of negatively charged electrons in orbitals around the nucleus. In general, the number of electrons in an atom tends to equal the number of protons so electromagnetic charges are balanced and atoms are electrically neutral. *Ions* are atoms or particles with net charges when total electromagnetic charges aren't exactly balanced.

2. Protons and neutrons are each composed of 3 elementary *quarks*. Quarks and their composite protons and neutrons are bound tightly together by gluons of the strong force to form atomic nuclei.
3. Positively charged protons normally repel each other, but if enough kinetic energy, spatial velocity, forces them close enough the strong force which holds their quarks together also binds the quarks of adjacent protons and neutrons together to form atomic nuclei. This occurs because the strong force is roughly 100x stronger than the electromagnetic force but has a very short range.
4. The number of positively charged protons in the nucleus determines which element the atom forms. There are 92 naturally occurring elements from hydrogen, the lightest with one proton, to uranium, the heaviest with 92 protons. The elements and their characteristics are described in the *Periodic Table*. Additional elements have been artificially created but most are unstable and quickly split into lighter atoms of the natural set. The very short range of the strong force limits the size of nuclei.
5. Each element may have several different *isotopes* corresponding to the number of neutrons in the nucleus. Neutrons are also composed of 3 quarks held together by the strong force.
6. Since positively charged protons, and negatively charged electrons have opposite electric charges the heavier protons tend to attract electrons to fill orbitals around them to form atoms of the element determined by the number of protons.
7. Atoms and molecules are essentially bound entanglements of continuous particle interactions, and constitute a major part of the entanglement, or universal information network that constitutes the fundamental information structure of the observable universe. Most of the complexities of atomic and molecular structures emerge naturally from the simple rules that govern the interactions of free particles. Thus, atomic and molecular matter is an emergent phenomenon that arises naturally from inter-particle interactions according to the rules of the complete fine-tuning.
8. Thus, most of the complex equations that describe atomic and molecular matter aren't part of the program that actually computes the universe. Instead, these equations are *descriptions* of the *aggregate behavior of the elemental program* that actually computes elemental particle events. All the emergent structure of the universe is simply the manifestation of individual particle interactions at the aggregate level.
9. In atoms, electrons are attracted to the opposite charge of protons in the nucleus and drawn towards them, however in most cases they don't have enough energy to react with a proton to form a neutron. The mass of a neutron is significantly greater than that of a proton and electron combined. So, for a reaction to occur there must be enough additional energy to be converted into the additional mass necessary to form a neutron. This can only occur with very high velocities or intense gravitational fields that provide enough intrinsic velocity energy to be converted into the necessary additional mass.

10. This does occur in extreme cases as neutron stars and black holes where atoms are crushed by intense gravity and electrons and protons do combine to form neutrons and all the atoms of the star collapse to the size and density of their nuclei.
11. Thankfully in most cases electrons don't carry enough energy to combine with protons to form neutrons. Thus, it's only the slight mass disparity between neutrons, and protons plus electrons, that prevents all atoms from collapsing into neutrons and all the ordinary matter in the universe from disappearing! A profound example of how the universe is very finely tuned to maintain its structure.

PHOTONS

1. Photons of electromagnetic energy serve the primary function of carrying packets of energy back and forth between material structures within the universe. Photons are packets of energy in the form of the spatial velocity of waves. The faster the waves vibrate the more energy they carry, and the shorter their wavelength. This is because photons all travel at the speed of light, so faster vibrations result in shorter wavelengths.
2. The transfers of energy within the universe by photons is pervasive and is a primary means to transfer energy that allows events and processes to occur.
3. Because the wavelengths of photons are precisely determined by the processes that produce them, resulting electromagnetic spectrums carry an enormous amount of information about the processes that produce them, and that they interact with.
4. Spectral analysis is one of the richest sources of information about the processes and structures of the universe.

ATOMIC NUCLEI

1. The scale of atomic nuclei is roughly femtometers, or 10^{-15} or a quadrillionth of a meter. Protons and neutrons are roughly a femtometer in diameter, The diameter of the nucleus is in the range of 1.70 fm for the lightest element hydrogen (the diameter of a single proton) to about 11.7 fm for the heaviest natural element uranium. and the range of the strong force that binds nuclei dies off quickly beyond a few femtometers.
2. In atomic nuclei the mutual repulsion of protons is overcome by the strong force which is approximately 100x the strength of their repulsive positive electrostatic charges at that scale, though it quickly dies off with distance.
3. Protons and neutrons are each composed of 3 quarks bound by the strong force which is mediated by gluons. Protons are composed of two up quarks of charge +2/3*e* and one down quark of charge −1/3*e* which additively account for the proton's net charge of +1. The rest masses of quarks contribute only about 1% of a proton's mass. The remainder of a proton's mass is due to quantum chromodynamics binding energy, which

includes the kinetic energy of the quarks and the energy of the gluon fields that bind the quarks together.

4. Neutrons are composed of 1up quark of charge +2/3*e* and 2 down quarks, of charge −1/3*e* which additively account for the neutron's net charge of 0*e*. The number of neutrons in a nucleus only minimally affects the atom's chemistry but does add to the mass of the atom and affect its nuclear reactions.
5. The 3 quarks that compose protons and neutrons are held together by the strong force mediated by gluons. When protons are forced together with sufficient energy to overcome their electrostatic repulsion the *residual strong force* that holds their quarks together also binds the nucleons together to form atomic nuclei.
6. The force carrier particle of the strong interaction is the gluon, a massless gauge boson. Unlike the photon in electromagnetism, which is neutral, the gluon carries a *color charge*, which is the charge of the strong force. Quarks and gluons are the only fundamental particles that carry color charge, and hence they participate in strong interactions only with each other. The strong force is the expression of the gluon interaction with other quark and gluon particles.
7. The strong interaction is mediated by the exchange of gluons that act between quarks, antiquarks, and other gluons. Gluons interact with quarks and other gluons by way of color charge. Color charge is analogous to electromagnetic charge, but it comes in three types (±red, ±green, and ±blue) rather than one, which results in a different type of force, with different rules of behavior. These rules are detailed in the theory of quantum chromodynamics (QCD), which is the theory of quark–gluon interactions.
8. All three colors mixed together, or any one of these colors and its anticolor, is "colorless" or "white" and has a net color charge of zero, and is stable with respect to the strong force. Color charges are the charges of the strong force and have nothing to do with actual colors.
9. A baryon is composed of three quarks, which must be one each of red, green, and blue colors; likewise, an antibaryon is composed of three antiquarks, one each of antired, antigreen and antiblue. Mesons are composed of one quark and one antiquark; the primary function of mesons is to mediate the strong force among protons and neutrons in the nucleus.
10. Atoms are stable neutral composites of protons and electrons where the numbers of the two + and – electric charges are balanced. In contrast the three color charges are balanced to form stable protons and neutrons when one color of each of the 3 color charges is present, and the result is a color neutral or 'white' particle.
11. Individual protons and neutrons are bound by continuous exchanges of color charges among their quarks by gluons. Gluons carry two color charges each, a color charge and an anticolor charge of a different color.
12. For example, a blue quark can transfer a blue-antigreen gluon to a green quark thereby swapping their color charges. The blue quark is transformed into a green quark by transferring its blueness and subtracting anti-greenness which leaves it green. In turn, the green quark becomes a blue quark because its greenness is cancelled by the antigreen charge of the gluon and it picks up the gluon's blue charge. In a similar manner all proton and neutron quarks continually swap color charges by transferring gluons.
13. Red-antiblue gluons switch red and blue charges of quarks; red-antigreen gluons switch red and green charges; blue-antired gluons blue and red charges; blue-antigreen gluons

blue and green charges; green-antired gluons green and red charges; and green-antiblue gluons green and blue charges.

14. There are also two additional gluons that contain quantum superpositions of red and blue charges and anti-charges making a total of 8 gluons. However, there are no red-antired, blue-antiblue, or green-antigreen gluons because they would be neutral white and have no effect.
15. Each of the three up and down quarks can have any of the 3 color charges, but the total color charge within both protons and neutrons must include each of the 3 color charges to be white, or color-neutral. Color charges are continually swapped between all pairs of quarks by one-way gluon transfers. This is how the strong force binds up and down quarks together to form stable color-neutral (white) protons and neutrons.
16. Antiprotons and antineutrons are composed of the equivalent antiquarks and have 3 anticolor charges that sum to white, but these antiquarks are bound by the same 8 gluons.
17. The strong force has a residual effect outside individual protons and neutrons that overcomes the electrostatic repulsion of the tightly packed protons to hold the particles of the nucleus together to form atoms. This *residual strong force is also called the nuclear force* and is mediated by the transfer of mesons, which are combinations of a quark and an antiquark. The nuclear force is converted to the intense energy of nuclear power, atomic and hydrogen bombs when released by fission or fusion of nuclei.

SPATIAL VELOCITY MODEL

1. In CTOE all forms of mass-energy are forms of spatial velocity, and all forms of spatial velocity are forms of mass-energy. For example, kinetic energy is linear spatial velocity, heat the average kinetic energy (spatial velocities) of molecules, photons are the vibrational spatial velocity frequencies of wave packets. Thus, the energetic charges of the three standard forces of gravitation, electric charge, and the strong force charges are all different forms of intrinsic spatial velocity.
2. As described in the chapter on general relativity, masses are fields of intrinsic spatial velocity in the form of hyper-fine vibrations of space itself, and the two electric charges are fields of intrinsic helical and anti-helical spatial velocity.
3. If this is correct then the three charges of the strong force would be modeled as three orthogonal local extension-contraction pulsings of space itself analogous to elastic rubber bands continually stretching and contracting in each of the three dimensions. Anti-color charges would be identical but opposite elastic spatial velocities such that red and antired would cancel. Sets of three orthogonal elastic pulsings would be necessary to form stable states.
4. This model explains both the existence of three separate color charges due to the existence of three spatial dimensions, and the fact the strong force is strongly local and loses strength with its limited stretch range.

ATOMS & ORBITALS

1. The diameter of atoms ranges from about 30 to 300 picometers where a picometer (pm) is one trillionth (10^{-12}) of a meter. Thus, atoms are over 10,000 times the size of their nuclei. This is roughly the scale of a pea at the center of a racetrack with orbiting sand grains bound by the electrostatic force to the pea.
2. Electrons are bound in atoms by the opposite charges of nuclear protons and continually oscillate around them because they are unable to either combine with or escape from them. Bound electrons oscillate around the nucleus forming standing waves of the probability distribution of where the electron might be at any moment with respect to the nucleus.
3. The forms bound electron waves take around nuclei are called *atomic orbitals*. The basic principles underlying the forms of atomic orbital are fairly simple through the actual resulting forms in multi-electron atoms become quite complex due to electron-electron interactions and the imperfect spherical attraction of multi-proton nuclei (Wikipedia, Atomic orbital).
4. Because they are constrained by the attraction of nuclear protons bound electrons settle into *harmonic standing waves centered on the nucleus*. Harmonic waves are standing waves with an integer number of nodes that maintain their forms over time. They are analogous to violin strings fixed at both ends, which can only vibrate in a standing wave of one, two, three, or more integer numbers of nodes when plucked.
5. Because electrons form standing waves their energies become fixed. Each different standing wave has a specific energy and for an electron to jump from one orbital to another it must absorb or emit a specific amount of energy in the form of a photon. The specific frequencies of the photons emitted or absorbed accounts for the distinctive spectral colors and lines of the various elements, and the fact that atomic orbitals have discrete energies is the origin of quantum theory.
6. The quantized energy levels result from the relation between a particle's energy and its wavelength. For a confined particle such as an electron in an atom, the wavefunction takes the forms of standing waves. Only stationary states with energies corresponding to integral numbers of wavelengths can exist; for other states the waves interfere destructively, resulting in zero probability density.
7. A more accurate analogy is that of a circular drum head whose circumference is fixed to the drum rim. Depending on how it’s struck it vibrates as a standing wave with one or more nodes and the waves produced in the drumhead are very similar in form to those of electron orbitals. Wikipedia, Atomic orbital has some excellent animations.
8. So, the secret to understanding electron orbitals is they are all the possible modes of dimensional oscillations of standing waves with increasing numbers of nodes in 3-space around a center that constrains them. This is the simple key to understanding electron orbitals and underlies the periodic table of elements.
9. Atomic orbitals form successive *shells* of increasing radius around the nucleus. Electrons in an atom are uniquely described by *4 quantum numbers* and obey the Pauli exclusion principle so that no two electrons in an atom can have the same 4 quantum numbers. The *first quantum number n denotes the shell* and is simply the number of harmonic nodes electron waves in that shell have; 1, 2, 3, etc.

10. The second quantum number l is the *azimuthal quantum number* and ranges across all integer numbers such that $0 \leq l \leq$ n-1. Thus, for each quantum number n there is a set of l+1 quantum numbers corresponding to the number of possible harmonic wave forms with n nodes. The azimuthal quantum number basically describes the orientations of possible standing wave forms relative to the 3 spatial axes. There are 3 possible identical harmonic waveforms, one along each axis.
11. The *3rd quantum number m_l, the magnetic quantum number*, describes the magnetic moment of an electron in an arbitrary orientation and is also an integer that varies within the subshell l_0 such that $-l_0 \leq m_l \leq l_0$. So, for example for subshell l=2, m_l would take on the values -2, -1, 0, 1, 2 corresponding to the possible harmonic wave forms for that n shell and l subshell. All the m's within all l's for a given n correspond to all the possible harmonic wave forms with n nodes, and together for all n's these define all possible orbitals for an atom.
12. The number of possible waveforms a spherically centered standing wave of n nodes can have in 3-space is n^2. However, two electrons can assume the same orbital waveform if their spins are oppositely oriented so the maximum number of electrons in a shell becomes $2n^2$. *Spin, s, is the last of the 4 quantum numbers* and is always plus or minus ½ (spin up or spin down) since the electron's spin is ½.
13. Thus, the possible orbitals electrons can occupy in an atom is simply the number of possible harmonic waveforms an electron wave can symmetrically assume centered on a nucleus.
14. Orbitals are the waveforms that actual electrons must assume when they are filled. The actual number of electrons in a neutral atom is equal to the number of protons so the electromagnetic charges are balanced, and the number of protons determines the element.
15. The orbital forms shown in most illustrations are those of ideal individual harmonic waves. They are those a single electron would assume around a single proton as it increased or decreased its energy and jumped from orbital to orbital. However, the presence of multiple electrons occupying orbitals in a single atom distorts their orbital forms due to the mutual repulsion of electrons and the necessary presence of multiple protons so the positive charge of the nucleus is not exactly spherically symmetric.
16. Thus, though the principles underlying electron orbitals are fairly simple the forms they actually take in atoms become quite complex with increasing atomic number due to the mutual repulsion among electrons, including the screening of positive nuclear charges from electrons in further out shells, the uneven attraction of multiple protons in the nucleus, and even relativistic effects coming into play in outer orbitals.
17. In more technical terms the electron wavefunction oscillates around the nucleus according to a time independent (unchanging) Schrödinger wave equation, and orbitals are its standing waves. The standing wave frequency is proportional to the orbital's kinetic energy. The real part of the Schrödinger equation gives the form of the orbital, and the imaginary part gives the probability distribution of finding an electron at a particular location within it.
18. Because they exist as bound entanglements the dimensional relationships of electrons and protons are exact in terms of energy conservation, which is of course the basis of quantum theory. However, when these conserved energy relationships are viewed in terms of positions and velocities of electrons relative to the nucleus, they are subject to the processor cycle conflations as viewed from an observer frame, which is why they

appear as harmonic standing wavefunctions within which the actual position and velocity of the electron appears probabilistic.

MOLECULES & MATERIALS

1. Molecules and materials are groups of multiple atoms held together by their electromagnetic forces. They are essentially all the ways in which the electromagnetic structures of the 92 natural atoms combine to form all the structures of the observable universe. Due to the incredible richness of the complete fine-tuning the number of materials and the emergent hierarchies they form in aggregate is truly amazing. The following is a brief overview of types of materials.
2. There are *several of types of chemical bonds*, molecular matter with covalent bonds (outermost pairs of electrons shared), ionic bonds, metals, crystals, and glasses. Molecules are groups of two or more atoms held together by covalent or ionic chemical bonds. Aggregates of molecules of a single type are called chemicals.
3. Ionic bonding is a type of chemical bonding that involves the electrostatic attraction between oppositely charged ions, or between two atoms with sharply different electronegativities, and is the primary interaction occurring in ionic compounds. It is one of the main types of bonding, along with covalent bonding and metallic bonding.
4. A *covalent bond* is a chemical bond that involves the sharing of electrons to form electron pairs between atoms. The stable balance of attractive and repulsive forces between atoms, when they share electrons, is known as covalent bonding. For many molecules, the sharing of electrons allows each atom to attain the equivalent of a full outermost valence shell, corresponding to a stable electronic configuration. (Atoms that have an almost full or almost empty outermost valence shell tend to be very reactive.) For example, two hydrogen atoms can combine to share their single electrons so the single shell of each appears to be completely filled by the two shared electrons.
5. Atoms with outermost shells not completely filled tend to fill those shells by sharing electrons with other atoms. Atoms with outermost shell completely filled tend to be stable and chemically non-reactive. When atoms combine in molecules outer atomic orbitals become distorted into molecular orbitals and the specifics of how they form and their complex properties determine the laws of chemistry and thus the structure and interaction rules of molecular matter. Thus, chemistry and all mass-energy structures are the emergent results of the electromagnetic interactions of protons and electrons,
6. Metals are materials in which metallic atoms held together by metallic bonds form loosely organized lattices of atoms interspersed with single outermost electrons rather than individual molecules. The electrons tend to be loosely bound to individual metallic atoms so they are more easily displaced and able to flow through the metal. When new electrons flow into a metal their electrostatic repulsion pushes existing electrons through the lattice producing an electrical current. This accounts for the conductivity of metals. Due to the nature of the metallic bond metals also tend to be ductile and malleable, i.e., they can be formed into different shapes.

7. Crystals are solid materials whose constituents are arranged in a highly ordered microscopic structure, forming a crystal lattice that extends in all directions. Macroscopic crystals are usually identifiable by their geometrical shape, consisting of flat faces with specific, characteristic orientations. Crystals are composed of lattices of atoms that form along regular orientations characteristic of the type of crystal rather than individual molecules. Most geologic materials (rocks and minerals) are composed of crystals, often fine and mixed in rocks and minerals and their breakdown into sands, silts, and clays.
8. Glasses are non-crystalline, often transparent, amorphous solids that can be formed into any shape. The atomic structure of a glass lacks the long-range periodicity observed in crystalline solids. Due to chemical bonding constraints, glasses do possess a high degree of short-range order with respect to local atomic structure.
9. In addition, materials exhibit *three states of matter* depending on temperature and pressure. Solids are lower temperature and/or higher-pressure states in which the kinetic energies of individual particles isn't sufficient to overcome their electrostatic binding energies. In gases at higher temperature or lower pressure, the kinetic energy of individual particles is sufficient to overcome their molecular binding energies and composite molecules split into simpler molecules or individual atoms.
10. Liquids are an intermediate state in which particles are bound firmly but not rigidly. They are able to move freely around one another, resulting in a limited degree of particle mobility. As temperature increases, the increased energetic vibrations of the molecules cause distances between the molecules to increase. When a liquid reaches its boiling point, the cohesive forces that bind the molecules closely together break, and the liquid changes to its gaseous state. If the temperature is decreased, the distances between the molecules become smaller. When the liquid reaches its freezing point molecules will usually lock into a very specific order, forming crystals, and the bonds between them become more rigid, changing the liquid into its solid state
11. Plasmas, the 4^{th} state of matter, are characterized by the presence of a significant portion of charged particles in any combination of ions or electrons. Plasma is the most abundant form of ordinary matter in the universe, but is relatively rare in stable environments such as Earth. Plasmas are created by intense temperatures and electromagnetic fields disrupting the electromagnetic structures of atoms and molecules.
12. In addition, chemical reactions of many types are common among different types of molecules and materials. The result is the amazing complexity of the billions of chemical processes that emerge throughout the observable universe, including, but not limited to, the biological process of life.

THE WEAK FORCE

1. The weak force is unlike the other forces in that it doesn't form bound states and its charge carrier bosons are massive (have mass). It is mainly involved in mediating fission and fusion of atomic nuclei.

2. The weak force is carried by W+, W- and neutral Z^0 bosons, which though they differ in mass, give the appearance of +, - and neutral varieties of a single WZ particle.
3. The +, -, and 0 are these particle's electric charges. The actual charge of the weak force is not even well-defined.
4. Thus, though the particles of the weak force are integer spin bosons, they behave more like other massive particles, and the weak force seems less like a force than just a specific mechanism that governs certain particle interactions.
5. W, and Z mediated interactions are also unusual in violating parity (P), and charge-parity (C-P) conservation.
6. So, even through the weak force seems to be theoretically unified with the electric force in *electroweak theory*, it seems somewhat questionable whether it's actually a fundamental force, and thus whether there are actually 4 fundamental forces, rather than just 3, the well-defined strong, electric, and gravitational forces that respectively form the nuclei, atoms and molecules, and large-scale structures of the universe.
7. And isn't it interesting, and surely with much deeper meaning, that the 3 regular forces of the universe have 1, 2, and 3 fundamental charges in descending order? What are we to make of that?

THE HIGGS MECHANISM

1. In the Standard Model of particle physics the masses of massive (having mass) elementary particles are due to their interaction with the Higgs field, which permeates all space. This includes the masses of leptons, quarks, and W and Z bosons. This occurs through a process called symmetry breaking in which the Higgs field interacts with particles that have a property called weak isospin.
2. The theory is that the Higgs field has a non-zero value throughout the universe, and particles that interact with it experience a resistance to motion, similar to the way that objects moving through a viscous fluid experience resistance. This resistance, in turn, gives rise to the particle's mass. This is somewhat similar to the CTOE theory of mass as fields of intrinsic spatial velocity and bears further study.
3. The discovery of the Higgs boson in 2012, predicted by the theory, lends credence to the theory. The Higgs boson has even parity and zero spin. Since it has zero spin (no intrinsic angular momentum) it's called a *scalar (no directional component) boson* in contrast to *vector bosons* which have integer spins and thus a directional component of intrinsic angular rotation.
4. This is due to the fact that the Higgs boson is an excitation of the Higgs field which is a scalar field. Excitations of fields manifest as particles in particle physics.
5. In quantum field theory, particles are generally understood to be excitations of fields. According to quantum field theory, all particles are described as excitations of their corresponding quantum fields. Each type of particle, such as electrons, quarks, or photons, is associated with a specific field, and the properties of the particle, such as its mass, spin, and charge, are determined by the properties of the corresponding field.

6. In quantum field theory, particles are not considered as discrete, independent entities, but rather as manifestations of their underlying quantum fields. These fields permeate all of space through time, and particles are thought of as localized excitations or disturbances of these fields. The more energy a disturbance has, the more massive the particle associated with that disturbance is, as the energy is converted into its mass.
7. Quantum field theory provides a unified framework for describing the behavior of all particles and their interactions, and it has been extremely successful in predicting and explaining a wide range of physical phenomena, from the behavior of subatomic particles to the properties of materials and the behavior of the universe on a large scale.
8. This is similar to CTOE, in which particles are excitations or energetic actualizations of the underlying virtual nature of the quantum vacuum, as encoded in the complete fine-tuning. In CTOE, the quantum vacuum is a computational rather than a dimensional space, so rather than fields pervading all (dimensional) space, the intrinsic nature of the quantum vacuum computational space exhibits all aspects of the complete fine-tuning virtually, and when energetically excited may actualize particle-antiparticle pairs in which particle property values sum to zero.

REVIEW OF MATERIAL EMERGENCE

1. So, emergence begins at the atomic level more or less. Atomic and molecular structures emerge automatically from the way that electrons, protons and neutrons interact, from the rules that actually compute their interactions as encoded in the complete fine-tuning.
2. Electron orbitals, and thus all chemistry and the structure of all matter emerges from the possible harmonic forms bound electron waves can take around aggregates of protons formed by the strong force, and the quantum nature of electron and other particle waves is the result of the space time conflations in the processor cycles as the observable universe is computed.
3. So, a small set of relatively simple particle interaction rules produces the atoms and molecules that compose all material structures; the mutual attraction and repulsion of electrons and protons, the inability of electrons to combine with protons at normal energies, the resulting possible orbital forms of standing harmonic electron waves around nuclei, the strong force binding of proton and neutron quarks in nuclei, and the large-scale structures formed by gravitational attraction.
4. Thus, the structure of the observable universe from atoms on up is emergent rather than directly computed by the universal processor. All the actual computations of reality occur at the particle and particle component level, and larger scale structures automatically emerge from aggregates of bound particles that manifest the rules of these elemental computations. This is how all the incredible complexity of the observable universe emerges from the finely tuned interplay of the simple elemental rules that actually compute them. This greatly simplifies the computational structure of reality. It's the incredibly amazing complete fine-tuning that is responsible for the wonderfully meaningful complexity of all the myriad emergent structures that are its stochastic aggregate manifestations.

THE UNIVERSAL INFORMATION COMPLEX

1. As described in the section on *Fundamentals*, the observable universe consists of only the complete exact information of what it is in a continual process of recomputation from state to state in each tick of present moment time.
2. At the elemental scale the complete information of the universe takes the form of the *entanglement network* described in *Fundamentals*, but at the emergent scale it is better described as the *universal information complex*.
3. The universal information complex is the complete present moment information state of the entire observable universe resulting from the continual evolution of computational interplay of the three primary forces on the information of the elemental particles and particle properties.
4. The continual recomputation of the data state of the observable universe creates an implicit information structure, stretching back to the big bang, that is completely exact, unalterable, and entirely logically consistent and logically complete. This is the complete information history of the observable universe of which only the current present moment slice exists. The universal information complex is the current present moment slice of this information history and is all that actually exists. It is the current information state of the observable universe stored entirely in the information that particles are in the present moment.
5. At the emergent scale, the universal information complex is an enormously complex structure that exhibits vast multi-scale granularity, hierarcality, causality, dimensionality, and interrelationships within the continuous interconnected whole of the observable universe.
6. Human observers tend to conceptualize the universal information complex in terms of discrete interrelated things, defined by sets of characteristics, undergoing causal processes, all governed by the *logic of things* and how they interact and are related. This is expressed in the universal logic of their various languages.
7. However, the reality is enormously more complex, as it includes the exact complete information of everything down to the level of elementary particles, and every interconnected emergent hierarchy, network and relationship of the entire observable universe, whereas humans extract individual things on an ad hoc basis conceptualized in terms of only a few currently relevant characteristics and relationships. This will be described in more detail in the section on *The Simulation*.
8. In the universal information complex, everything is strongly and continuously interconnected at more elemental scales and everything emergently self-organizes into vast hierarchies of somewhat amorphous discernable structures. E.g., forests composed of various species of trees, each tree with leaves, twigs, branches, and a trunk inhabited by great populations of various life forms. And the forest itself part of a hierarchy of Earth's biosphere, part of its ecosystems, and so forth up and down and across the vast myriads of hierarchies of the universe.

REALITY PROGRAMS

1. Because the observable universe is created and evolves computationally, it is effectively a program, a running program that continually recomputes the evolution of its current information state from its previous information state according to the rules of the complete fine-tuning.
2. Because emergence creates discernable higher scale structures, this universal program can be said to consist of uncountable myriads of subprograms at all scales, each running in computational interaction with an environment composed of other programs.
3. We can call all these programs of the universe reality programs because they all compute information in the universal medium of existence, and thus manifest as all the real existing things and processes of the universe.
4. While any subset of the universe can be considered a subprogram and analyzed as such the universal program results in discrete emergent structures or domains that naturally emerge as programs running in an environment of other programs.
5. Programs include everything from chemical reactions, to the flows of streams and rivers, the circulation of atmospheres, the erosion of mountains, down to the slightest movement of sand grains by breezes. Every imaginable process is in effect a program since every process is computational.
6. Biological beings are quintessential examples of running reality programs. All biological beings are running reality programs that computationally interact with their environment of other reality programs to live their lives.

LIVING PROGRAMS

1. As we have seen in previous sections, everything that exists is the complete exact information of what it is down to the continual computational processes that sustain and recreate its existence in the current universal present moment, and the information of what everything is, is the computational result of its interactions with the information of all the other things that have made up its information environments and all its precursors throughout the history of the observable universe.
2. And this results in the information that things are including much information of the other things it has interacted with over the history of its existence. Thus, the information that things are includes information about other things. This ability to understand other things, past and present, from the information of collections of things is the Sherlock Holmes principle that is the fundamental basis of all knowledge.
3. So as reality programs interact with their environments, they gain information about those environments. The key to life is A. reality programs that have gradually evolved to explicitly store relevant information about their interaction environments they use to choose among purposeful actions, and B. incorporating information about their own

information in the form of RNA or DNA to enable them to reproduce their kind so as not to have to redo the interminable process of re-evolving it.

4. Life is programs that have evolved the ability to act purposely, that is to perform top-down computations based on the incorporation of information *about* things (environments) into the information *of* themselves, and the ability to make purposeful decisions based on this information. And the inclusion of information (software) *about* themselves in the information *of* themselves that enables them to reproduce themselves.
5. These abilities evolved gradually over the history of life on Earth under the pressure of selection. E.g., a differential ability of diverse populations of single cell organisms to sense and move to favorable conditions of light, temperature, salinity or nutrients would lead to survival of those more adapted to those environments.
6. Thus, life is a profoundly major evolutionary development in the information history of the observable universe. It marks the first stage in the evolution from information being *of* things to explicitly include information *about* things. The importance of this major inflection point in the information history of the observable universe can not be overstated.

ORIGIN OF LIFE

1. Abiogenesis, the origin of life from non-living precursors, is still only partially understood by current science. There are a number of competing hypotheses but the most promising seems a combination of the RNA world, and lipid world theories.
2. The RNA world theory proposes that the first life was RNA based. Small RNAs can catalyze all the chemical groups and information transfers required for life. RNA both expresses and maintains genetic information in modern organisms; and the chemical components of RNA are easily synthesized both under current conditions and conditions that approximate the early Earth, which were very different from those that prevail today.
3. The RNA world theory is supported by experiments demonstrating that under favorable conditions all four ribonucleotides, the chemical components of RNA, are produced from precursor chemicals and can self-assemble to create RNA chains. The four ribonucleotide components of RNA are fairly common chemicals throughout the universe.
4. RNA strands can also begin copying themselves to replicate. RNA replicase can function as both code and catalyst for further RNA replication, i.e., it can be autocatalytic.
5. The lipid world theory suggests that bilayer lipid membranes, the major components of cell membranes also form naturally under favorable conditions. The lipid world theory postulates that the first self-replicating object was lipid-like. Phospholipids form lipid bilayers in water under agitation - the same structures as in cell membranes. These, and similar molecules known to be present on early Earth both form membranes.
6. These bodies may expand by insertion of additional lipids, and may spontaneously split into two offspring of similar size and composition. The main idea is that the molecular composition of the lipid bodies is a preliminary to information storage, and that evolution led to the appearance of polymers like RNA that store information protected within lipid

protocells. The combination of these two naturally occurring chemistries forms a natural precursor to cellular life.

7. Once we have self-replicating RNA chemistry protected within lipid membranes, we have the essential components of cellular life. And assuming replication produces different populations of protocells with different RNA sequences over time that differentially affect viability, those RNA sequences that convey greater 'fitness' will be gradually selected.
8. This can be the case even before RNA sequences explicitly encode information about the structure or function of their cells since RNA automatically codes for production of various proteins.
9. The transition from RNA to DNA based life would begin when RNA began replications using thymine instead of uracil and ribose sugar instead of deoxyribose. Instead of RNA this creates DNA strands which are much longer, stronger, and long lasting.

DNA BASED LIFE

1. All life on Earth is DNA based. There are three domains of life. Eukaryotes are organisms whose cells have a nucleus containing their genetic DNA. The prokaryotes, bacteria and archaea, are single celled organisms without nuclei and store their DNA in the cytoplasm in circular strands. The nuclei and ribosomes of eukaryotes, and later chloroplasts of plant cells, are thought to have originated through the incorporation of separate single celled prokaryotes into one another.
2. DNA molecules are polymers and take the general form of long spiral staircases without a central pole, the double helix. The two side frames are strands of repeating sugar (deoxyribose) and phosphate groups, and each step consists of a pair of nucleobases, either cytosine (C) - guanine (G), or adenine (A) - thymine (T). The nucleobase steps connect a sugar on one side frame to a phosphate group on the other side.
3. Each DNA molecule is called a chromosome and species have evolved cells with different numbers of chromosomes. In humans, each cell normally contains 23 pairs of chromosomes, for a total of 46. Twenty-two of these pairs, called autosomes, look the same in both males and females. The 23rd pair, the sex chromosomes, differ between males and females. Females have two copies of the X chromosome, while males have one X and one Y chromosome.
4. Each DNA strand can contain hundreds of millions of nucleotides. Chromosome 1, the largest human chromosome contains approximately 220 million base pairs, and would be 85 mm long if straightened. Thus, DNA is highly compacted within cells.
5. DNA molecules can contain arbitrary sequences of base pairs. This allows DNA to serve as information storage devices where specific base pair sequences encode information for the development, functioning, growth and reproduction of all known organisms and many viruses.
6. The evolution of RNA and DNA information storage marks a profound inflection point in the evolution of information *of* things to include information *about* things. It enables the design and function of organisms to be encoded and passed down from generation to

generation under evolutionary selection, rather than having to re-evolve each time over millions of years.

7. The DNA on chromosomes is organized into genes delimited by promoters and terminators which mark the beginning and end of the gene, each gene coding for a specific function. A small fraction of genes code for the production of specific proteins used in cells, some genes appear to be remnants of viruses and horizontal transfers from other species but the function of many genes is poorly understood. It is clear they must code for all those aspects of organisms which can only be passed from generation to generation, including its instinctual imperatives.
8. More evolved biological organisms are incredibly complex computational systems, or programs, that include the code not only for construction, repair and function of all of their subsystems, but their simulations of self within environments, and decision-making systems as well. All this code is effectively the software of the organism that operates its biological hardware.
9. Software is information and must be stored as code within the organism in some form. In particular the decision-making and simulation systems must be stored as code in the brain. The logic this information takes can be inferred from the actions of the organism, though the exact form of storage in the brain is unclear. It is clear that the software rules must be inherited, so they are most likely stored in the little understood extensive 'noncoding' areas of DNA in a format that makes it possible to be translated into neural format, likely during the differentiation of brain cells.
10. This is an area with vast potential currently inhibited by the fact that biology seems largely blind to the existence of organismic software and especially its hereditary transmission through and encoding in DNA.
11. These software rules will be hierarchical, based on simple elementals that in aggregate result in all the complex decision-making of conscious intelligent minds. We know that relatively simple rules, e.g., those that govern the behavior of individual ants, and brain cells, produce ant superorganisms, and conscious minds in humans when acting in aggregate. We would expect the rules of the decision-making software of complex organisms to emerge as well from much smaller sets of elemental rules operating in aggregate. And we would expect the more fundamental rules to be encoded in the more primitive areas of the brain shared with more primitive organisms.
12. In particular, basic instinctual imperatives are likely passed from DNA in elemental forms. E.g., suckling as simple seeking of lactating breast by scent, followed by oral suckle response when lactating breast is orally found. The response then progressively augmented by learned touch texture of breast, and presence of mother. The presence of mother elemental is another fundamental code at least partially identified by first animated presence, as in the trailing bonding of ducklings and goslings. Many similar examples of the transmission of instinctual imperatives can be noted.
13. In the case of genes that code for proteins, the process is better understood, as RNA strands copy the gene from DNA in to their own nucleobase sequence and use it to construct the protein from amino acid sequences based on that. We must expect some similar process for the transcription of basic software elementals from DNA to brain cells. The basic information codes of neurons must first be understood and the sequences of so-called 'noncoding' genes may well offer clues.

14. The double helix of DNA is exquisitely designed to efficiently encode large amounts of information in a form both easily transmissible and reproducible.
15. First, the hydrogen bonds that hold the bases pairs on each rung together are relatively weak and can be broken and rejoined relatively easily. Thus, the two strands can be unzipped and rezipped down the middle around individual genes during the process of transcription to RNA for gene expression without damaging their structure.
16. Second, DNA is designed to be efficiently reproductible when cells divide ensuring that each daughter cell contains an exact copy of the parent cell's DNA. This process, called mitosis, ensures the genetic integrity of the organism is maintained as cells multiply to construct it. In mitosis chromosome pairs first line up at the cell's equator and are copied. Then each copy is pulled to a different pole of the cell as it divides along the equator to create two new identical cells.

MEIOSIS & SEXUAL REPRODUCTION

1. Human somatic (body) cells are diploid, that is they contain two copies of each of 23 chromosomes, one copy from father and one from the mother, for a total of 46 chromosomes. These pairs contain the same genes to encode the same functions but the genes vary reflecting the genetic differences of the parents from which they come. The exception is the sex chromosomes of which there are two distinct types denoted as X and Y. Female cells contain two copies of the X chromosome while male cells contain one X and one Y.
2. In contrast sperm and egg cells (gametes) are haploid, that is they contain only one copy of each chromosome. Thus, when they fuse in fertilization, the resulting cell contains two copies of each chromosome, one from the father and one from the mother, and becomes diploid able to grow into a new organism.
3. Gametes are produced in a two-step process called meiosis, in which diploid somatic cells first temporarily link chromosome pairs with some crossovers (swapping) of genes between pairs, next duplicate the crossed over chromosomes, and then split to produce two new diploid cells each with full pairs of chromosomes. In the second stage these two diploid cells divide again without reproducing their chromosomes to form a total of four new gamete cells, each with only one copy of each chromosome. It is these gametes (sperm and egg cells) that combine in sexual reproduction to form a fertilized zygote.
4. In this way the offspring of each generation are genetically distinct from either parent or ancestor and thus subject to progressive evolutionary selection.
5. Though there are a number of variations among species, this is the general process of sexual reproduction in which new organisms receive one copy of their chromosome pairs from the father and one from the mother, thus ensuring their genetic diversity.
6. Many other species reproduce asexually, essentially cloning themselves with little if any variation from generation to generation.

DEVELOPMENT OF THE EMBRYO

1. Upon fertilization the zygote begins a process of multiple mitotic divisions during which it develops into an embryo. When the embryo becomes able to survive on its own it is either born live from the mother's womb or hatches from its egg.
2. The development of the basic structure of the embryo takes place within the egg and involves a repeated process of cell differentiation as the original totipotent cell is transformed into pluripotent stem cells of the various structures and organs of the fetus.
3. This process of cell differentiation tends to recapitulate the development of the primitive ancestors of the organism back to very primitive forms indeed. Such as the first bilateral organisms with spinal cords, and even the dinosaur ancestors of some current birds, whose embryos still develop tooth buds and tails before later losing them.
4. In the first hours after fertilization, the zygote divides into multiple identical cells. In humans, approximately four days after fertilization, and after several cycles of cell division, these cells begin to specialize forming a hollow sphere of cells, called a blastocyst. The blastocyst has an outer layer of cells, and inside this hollow sphere, there is a cluster of cells called the inner cell mass. The cells of the inner cell mass go on to form virtually all of the tissues of the human body. Although the cells of the inner cell mass can form virtually every type of cell found in the human body, they cannot still form an entire organism. Thus, these cells are referred to as pluripotent.
5. The resulting cellular blastomere then differentiates from the single-layered blastula to the three primary layers of germ cells in mammals, the ectoderm, mesoderm, and endoderm. The ectoderm ends up forming the skin and nervous system, the mesoderm forms the bones and muscular tissue, and the endoderm forms the internal organ tissues.
6. The rules by which the original zygote differentiates into an embryo with adult structure and function must clearly be encoded in its genes, but how and how they are progressive expressed to create an adult is little understood. No doubt it is the result of a number of fairly simple logical steps cued by feedback from the developing fetus itself that result in the sequential expression of genes and differentiation of cells and their functions. In any case, the emergent result is a complete functioning organism.
7. To a limited extent these same rules are also involved in the regrowth of tissues to repair injuries. This occurs to a greater extent in species such as lizards which can regrow entire lost tails.
8. Normal somatic differentiated cells divide approximately 50 times in culture before entering a state of senescence in which cell division stops. This is called the Hayflick limit. Each time a cell divides, the telomeres on the ends of each chromosome shorten slightly. Cell division stops once telomeres shorten to a critical length. The aging of cell populations appears to correlate with the overall physical aging of an organism, however there is no clear correlation between telomere length and lifespan among species.

GENE TRANSCRIPTION & EXPRESSION

1. Cell differentiation occurs through epigenetic processes (alterations which leave DNA unaltered but change which DNA sequences are used or expressed) such as methylation which dampens the expression of particular DNA sequences by attaching methyl groups which inhibit the ability of RNA to copy and thus express them.
2. Cell differentiation is one of many examples of gene expression in which the information of a gene is transcribed into an active process. Simply stated, transcription is the duplication of a DNA sequence by RNA polymerase enzyme to form a matching RNA strand one base at a time, which is then used to express the function of the gene it copied, either to create a protein or perform a so called 'non-coding' function. RNA polymerase begins transcription at the promoter code for a particular gene and ends it at the terminator code.
3. The RNA sequence produced is identical to the DNA except that uracil (U) bases are substituted for thymine (T). Uracil makes RNA strands considerably weaker than DNA, partial strands of which can last for tens of thousands of years. RNA scaffolding is identical to that of DNA except that it alternates ribose sugars instead of deoxyribose.
4. During the transcription process the two strands of the double helix are unzipped from one other in the area along the gene for replication. After the transcription they are zipped up again to restore the double helix.
5. The human genome contains two copies of each chromosome, each with variants of the same genes. These variants of the same gene are called alleles. In gene expression one of the two alleles is selected for transcription. Which allele is selected depends on epigenetic factors or may be random in some cases. Various combinations of dominant or recessive alleles are responsible for factors such as eye color, blood type, and a number of genetic disorders. This is called Mendelian inheritance.
6. Some genes have dominant and recessive alleles, other genes exhibit co-dominance in which both alleles are expressed as in AB blood types, or incomplete dominance in which allele expression is mixed as in the case of red and white parent flowers resulting in pink daughter flowers. And many traits are polygenic, being influenced by alleles of multiple genes.
7. If a gene has both dominant and recessive alleles the dominant trait is expressed if one or both alleles are dominant, but the recessive trait is expressed only when both alleles are recessive.
8. There are ~37.2 trillion cells in an adult human, and around the same number of bacteria, fungi, viruses and other microorganisms that make up the human microbiome, mainly in the gut. Most of these are single unnucleated prokaryotic cells that average 1/10,000 the volume of human eukaryotic cells, so their combined volume and weight is a small fraction of the entire human communal organism.

TOP-DOWN & BOTTOM-UP COMPUTATION

1. Life is characterized by various degrees of intentional or purposeful decision making at the top-down scale of the living programs of individual organisms based on information

about both themselves and their environments. In general, such decision making has evolved to further the survival of the individual organism and its genetic heritage.
2. Though everything is actually computed at the elemental level by the universal processor, programs, especially those of higher organisms, can be said to exhibit *free will* in their ability to compute intentional actions not entirely determined by the programs that constitute their environments.
3. Though initially confusing, this doesn't contradict the fact that the universe actually computes everything at the most elemental level. Recall that human computer programs consist of high-level code sequences that compute high-level actions but are all actually executed in terms of elemental machine language operations. Thus, it's just two ways of looking at the same process, the elemental and emergent scale views. Of course, human programmers code human computer programmers and evolution codes the decision-making processes of living organisms.
4. Sets of elemental computations evolve complex emergent structures in aggregate including decision making structures which exhibit free will due to the quantum randomness of elemental computations. It's a false dichotomy to ask whether decisions are actually made at the elemental or by emergent level programs themselves. All emergent processes are just views of elementals in aggregate. They are just two ways of looking at the same identical process in reality.

FUNCTIONAL DESIGN OF LIFE

1. Biological organisms are quasi autonomous computational systems that function by means of their individual hardware and software. They do this using variants of a small set of functional subsystems common to most living organisms, and that are also necessary in general purpose robots.
2. These include sensory devices that input relevant data about the environment and the organism within it.
3. A real-time information model of the organism within its environment constructed and continually updated by sensory input.
4. A set of instinctual imperatives based on the fundamental instinct to preserve and optimize the individual self and its genetic heritage and to generate positive as opposed to negative feelings. These imperatives determine the purpose of the organism.
5. An imagination system which enables the organism to imagine nonexistent alternate possible future states of itself and its environment.
6. A valuation system that ranks feelings, both physical and mental, and which ranks alternative actions and enables choice among them.
7. A selection system which continually chooses actions based on valuations of expected results.
8. An activation system which translates mental decisions into actions.
9. In addition, organisms are designed with systems that monitor, maintain and repair themselves, reproductive systems, and consciousness which acts mainly as a high-level

quality control system. Even in complex organisms, almost all these processes including decision making take place unconsciously.

10. In summary, complex living organisms are quasi-autonomous reality programs that continually act to fulfill their instinctual imperatives by choosing among valuations of present moment feelings and imagined possible alternatives.
11. All living organisms exhibit some degree of free will because their computations, like those of all processes, exhibit quantum randomness at the particle scale and so cannot be exactly predicted from knowledge of their environments. Thus, humans and other complex species are semi-autonomous free willed, sentient, conscious biological robots.
12. The design of effective fully functional general purpose AI driven robots must be essentially the same. In fact, much can be learned about the functional design of humans and other complex species by designing and programming general purpose robots.

CULTURES & CIVILIZATIONS

1. In animals that care for their young relevant information is passed from generation to generation as the young learn from parents, siblings, and relatives by imitating their behavior. This greatly enhances the wealth of environmental knowledge, and thus survival success, as infants form their information models of themselves within their environments and is an additional step in the evolution of the information universe as the information of things further evolves to include information about things.
2. In social animals this process is carried one step further as relevant information is distributed among group members. This can include location of food sources, migratory routes, prey and predator behaviors, and many other types of information. Such collective information across group members and generations forms the *culture* of the group.
3. Human cultures are characterized by the additional information of technologies and tool making. These information structures include fire, pottery, tool and weapon making, clothes and shelter making, ornamentation and ritual. These are all information forms shared among group members and passed from generation to generation. They involve the production of autonomous information forms of use to the human programs that create them, and they also originate the information of property and ownership.
4. And human cultures domesticated animals and developed agriculture which involves coopting the gross decision making of other living programs for human benefit.
5. In social groups the distribution of information across group members creates an additional level of emergence as is especially seen in the collective actions of insects whose groups function as superorganisms due to the emergent manifestation of relatively simple computations of individual members in aggregate.
6. Large human groups self-organize into civilizations. Civilizations are characterized by divisions of labor, and thus of information knowledge. Subgroups are able to accumulate detailed knowledge of specific topics, thus enabling the collective wealth of information to grow well beyond the capabilities of individual members.

7. All these emergent stages involve the increasingly complex evolution of information about things into more and more complex and detailed forms than any individual is capable of.
8. Additional stages in the evolution of information structure of the universe are writing, the printing press, computers, the internet, AI, and eventually a global planetary intelligence in which planet Earth emerges as a single autonomous intelligent organism acting to further its overall wellbeing, from the emergent collective actions of humans and technologies in aggregate. This *Smart Planet* concept is explained in the final section of this pdf.

EMERGENCE OVERVIEW

1. The visible universe, which is but a minute part of the entire universe, contains an estimated 10^{81} material particles, all submicroscopic little bundles of immense vibrating energy in constant motion. Under the 3 structure forming forces these particles have self-organized into all the emergent galaxies, stars, planets, materials, chemicals and elements that compose the universe. This estimate doesn't include the equally vast number of photons, and neutrinos.
2. From the perspective of the particles themselves, they just continually play out their immensely energetic existences and aggregately act under relatively simple rules to create and maintain the vast unknown material structures they compose.
3. Planet Earth is composed of around 10^{51} material particles, which together make up all the enormously complex structures of its core, tectonic plates, oceans, mountains, geographies and so on down to the finest particles of dust floating in the sunshine. All of these systems are in constant motion and evolution under the energetic action of the particles that compose them.
4. In turn, approximately 10^{41} of the particles on the planet have self-organized into living cells, of which there are approximately 10^{30} on the planet that compose the biosphere. Of living cells around half are single celled organisms such as bacteria and archaea, and the other half have self-organized into emergent multicellular organisms.
5. All these cells are in constant energetic living internal chemical motion, continually vibrating with life. Thus, the cells all happily go about their chemical business unaware of both the particles that compose them and provide their energy, and the living organisms in turn created by their continuous chemical interactions in aggregate.
6. And as always, all such scales of emergence are a single computational unity designed and implemented by the active intelligent design of the complete fine-tuning as it is continually executed by the universal processor. The active intelligent design of the complete fine-tuning computes the continued integrated coexistence of all scales of emergence from the most elemental through all scales above it as the single vast enormous complex information structure of the observable universe.
7. In turn, the actions of individual humans and other organisms continuously manifest as many levels of emergence above themselves in the families, cultures, societies, technologies, and information sharing that compose the great sweeps of cultural evolution

and history from the earliest life on Earth to the present. And again, the individual elemental units, ourselves, have little if any knowledge of the vast hierarchies of emergence above us we continually create through our aggregate actions.

8. Thus, planet Earth is an unimaginably complex emergent hierarchical material, living information structure composed at all scales of uncountable highly interacting physical and chemical processes upon and in which seething multitudes of living cells exist many emergently self-organized into all the plants, animals and other living beings that cover our planet with life.
9. Viewed from the perspective of the cells themselves, complex life forms such as humans are merely the emergent manifestations of their continual communal aggregate actions. Just as the living cells that compose us are merely the emergent manifestations of the atomic particles whose energetic vibrations continually manifest them into existence. All these living cells have self-organized on the basis of information stored in DNA molecular storage devices which themselves are the emergent chemistry of the complete fine-tuning.
10. And further, behaviors, structures, organizations, technology, societies, cultures and civilizations based on the storage of information in language, writing, the internet, social media, etc. all emerge from human biology, which emerges from human DNA, which emerges from chemistry, which emerges from molecules, atoms and elementary particle interactions, all of which emerges from the complete fine-tuning. The lives of all the countless humans and other species throughout human history and the history of the planet. all so real in their thereness during their individual existences looking up at the same slowly evolving revolving moon.
11. And who knows what else is yet to come in the unending evolution of the universe and life on this unspeakably minute speck of a planet inhabited by unspeakably minute specks of all human and other lives, a few occasionally thinking unspeakably minute, fleeting and totally inconsequential fragments of information about it all like this one?
12. All this emergence is the active intelligent design in the ultimate manifestation of the complete fine-tuning of our universe. The complete fine-tuning implicitly contains all possible emergence, ours stochastically brought to life by the continual energetic computation of the universal processor computing the continual c spacetime velocity of the universe.
13. Truly all this is the ultimate miracle of miracles! Of which we are so immensely privileged to be but the minutest part in this minutest of moments of the vast history of the even vaster universe; but one of countless googles of information structures somewhere in a totally inconsequential tucked away downscale hierarchy of emergence.

IV: REALIZATION & THE SIMULATION

V: THE SMART PLANET