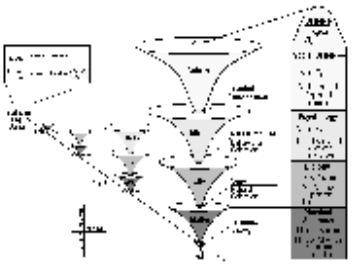
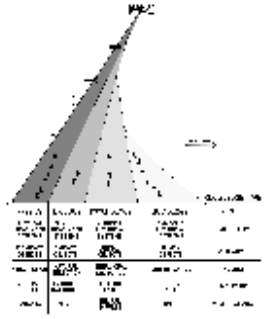
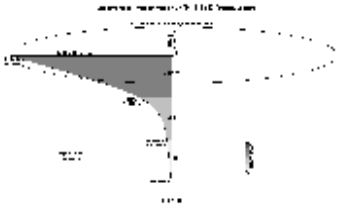


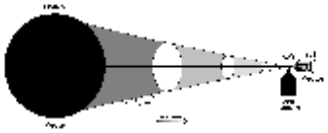


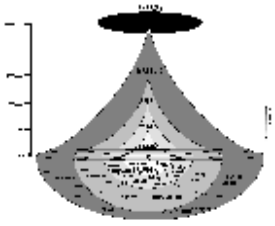
The Tree of Knowledge System:

A Manifesto for the Unity of Scientific Knowledge

Gregg Henriques, Ph.D.







The Tree of Knowledge System:
A Manifesto for the Unity of Scientific Knowledge

In his influential book, *Consilience: The Unity of Knowledge* (1998), Edward O. Wilson offers the hypothesis that all knowledge, from quanta to culture, can be united into a single, coherent conceptual framework. Wilson readily acknowledged his grand proposal stood as a hypothesis and that consilient unity among the sciences, particularly between the natural and social sciences, has yet to be achieved.

The Tree of Knowledge (ToK) System presented here offers a solution demonstrating the validity of Wilson's consilient hypothesis. The ToK System solves the consilient hypothesis by providing an understanding of the relationship between the evolution of complexity on the one hand and the organization of the sciences on the other.

You are invited here to tour the ToK System. The System is presented by offering a brief overview of the evolution of complexity from the beginning of time to the present. The figures of the ToK System follow, with each figure offering a different perspective on the ToK. There are 7 Figures of the ToK System in all. If the ToK System is correct, it provides a unified framework for all knowledge. Such a unification would carry significant implications.

This packet also includes two diagrams depicting the Standard Model of Elementary Particle Physics. Because there is so much scientific evidence for the Standard Model, any Universal Knowledge System must be consistent with this Model. The ToK System is, to the best of my knowledge, consistent with the Standard Model.

The Story of the Universe as Told by Modern Science

In the beginning, there was a sea of pure Energy. This Energy Singularity contained no Matter, space or time, but instead was made up of quanta. Quanta are irreducible units of energy. In Information Science terms, this irreducible unit can be considered a digit and the Energy Singularity can be thought of as a dimension made up of digits of quanta.

Approximately 15 billion years ago, there was a chain reaction in the Energy Singularity, called the Big Bang explosion, in which the pure Energy quanta began to freeze into chunks of Matter, called fermions. Fermions are the fundamental units of Matter that ultimately form all the Matter in the Universe. Fermions come in two types, Quarks and Leptons, and will be described in more detail later. The term Big Bang is used to describe the Energy-to-Matter chain reaction because it refers to the point at which the Material Universe “exploded” into being. Another important point is that, unlike the quanta, fermions occupy discreet bits of space and time. The Big Bang explosion generated Space and Time, as well as Matter.

Fermions (or chunked, frozen quanta) did not organize into atoms immediately after the Big Bang. Instead, the first atoms appeared about 300,000 years post-Big Bang. The reason is because fermions do not form into atomic systems at incredibly hot temperatures. In fact, it wasn’t until the Universe had cooled to approximately 3,000 degrees Kelvin that the first atoms could form. The first atoms were primarily Hydrogen and Helium. As the Universe continued to expand and cool, large collections of gases condensed and formed into stars and galaxies. This variation created many different types of Energy-Matter environments, which in turn led to the formation of a variety of different types of atoms. The atoms that were ultimately formed are, of course, represented and categorized in the Periodic Table. In particular environments that are neither too hot nor too cold, atoms link up through the process of covalent bonding, creating increasingly complex chemical systems.

One particular environment, found on a planet orbiting an average size star in the Milky Way Galaxy, was especially conducive to the formation of complex chemical systems. The complex chemical systems on Earth 4 billion years ago exhibited a wide variety of algorithmically complex behaviors. One behavior of a particular class of these complex chemical systems was the behavior of self-replication. That is, many chemical systems made copies of themselves. Through the process of replication, variation, and selection, these self-replicating chemical systems became increasingly complex and sophisticated, eventually forming huge strands of ribonucleic acid. Eventually, these self-replicating chemical machines formed into prokaryotes, which are primitive cells that lack a nucleus. Over the next ~3 billion years the prokaryotes eventually formed into eukaryotes (cells with a nucleus) and finally into large scale, multi-cellular organisms, which would be similar in complexity to a modern day plant or tree. Thus the span of time ranging from 4 billion years ago to 700 million years ago saw the evolution of life via natural selection operating on genetic combinations through time.

Starting at approximately 640 million years ago, a new type of multi-cellular creature emerged, creatures we call animals. Animals are unique in that they are multi-cellular organisms that move around their environment. This capacity for movement created the selection pressure for a computational control center that measures the organism's relationship to its environment and moves the organism toward beneficial environments and away from harmful environments. This computational control center is, of course, the nervous system. The nervous system represents a fundamental shift in complexity because behavior of these organisms is not fully restricted to the unfolding of the genetic program encoded in the deoxyribonucleic structure. Instead, animals can use neuro-information processing mechanisms to generate new behavioral outputs in response to novel environmental stimuli. In other words, they can learn to modify their behavior based on ontogenic experience. The nervous system begins as a set of simplistic neural reflex arcs made up of neural nets. It then becomes a reflexive control center for basic bodily functions (like temperature regulation). The nervous system evolves into a system capable of generating increasingly complex neuro-representations of the organism-environment relationship, which allows for increasingly sophisticated behavioral patterns, such parenting or cooperating. Finally, the nervous system becomes capable of manipulating the neuronally represented organism-environment relationship.

One can roughly trace the evolution of Mind, or nervous system complexity, from worms to fish to reptiles to birds to mammals. This took place from approximately 640 million years to 5 million years ago. Five million years represents the point at which humans share a common ancestor with our closest great ape relatives, the chimps and bonobos. The period between 5 million years ago and today saw the emergence of Culture, which occurred for one particular animal, the human animal.

The story told by archeologists and anthropologists is that climatic changes in river basins in Africa changed dense forests into savannah grasslands. This change in ecology required a change in morphology. This ape ancestor of modern humans had to "come down from the trees" and be able cover large amounts of territory. This adaptive pressure set the stage for bipedalism (~3.5 mil years ago), which in turn freed the hands from locomotive responsibilities. Freed hands created more opportunities for behaviors like tool making, which in turn created selection pressures for increased neuro-cognitive capacity. By about 1.6 mil years ago, Homo Erectus, one of our hominid ancestors, was making very complicated hand axes. Their brain volume was approximately twice that of a chimp and about two-thirds that of modern humans. These hominids almost certainly did not have language.

The evolution of language is thought to have occurred between 500,000 and 100,000 years ago. This period is associated with massive growth of the cortical structures, as well as changes in throat structures associated with language. This period is also associated with the emergence of modern Homo sapiens. The capacity for true language is unique to humans in the animal kingdom. The adaptive advantage of language is obvious. It allows for the efficient transfer of huge amounts of information, which in turn leads to greater knowledge and more effective coordination of behaviors. The reason it evolved in humans is intimately connected to the increased neuro-

cognitive abilities for mental manipulation. The ability to mentally transform objects in time set the stage for these mental objects and their transformations to be symbolically tagged. The mental objects are tagged as nouns and their transformations as verbs. The neuro-cognitive machinery that allows for the unique human capacity to easily acquire the linkage between symbols and objects is referred to as the Language Acquisition Device and is housed in the left hemisphere.

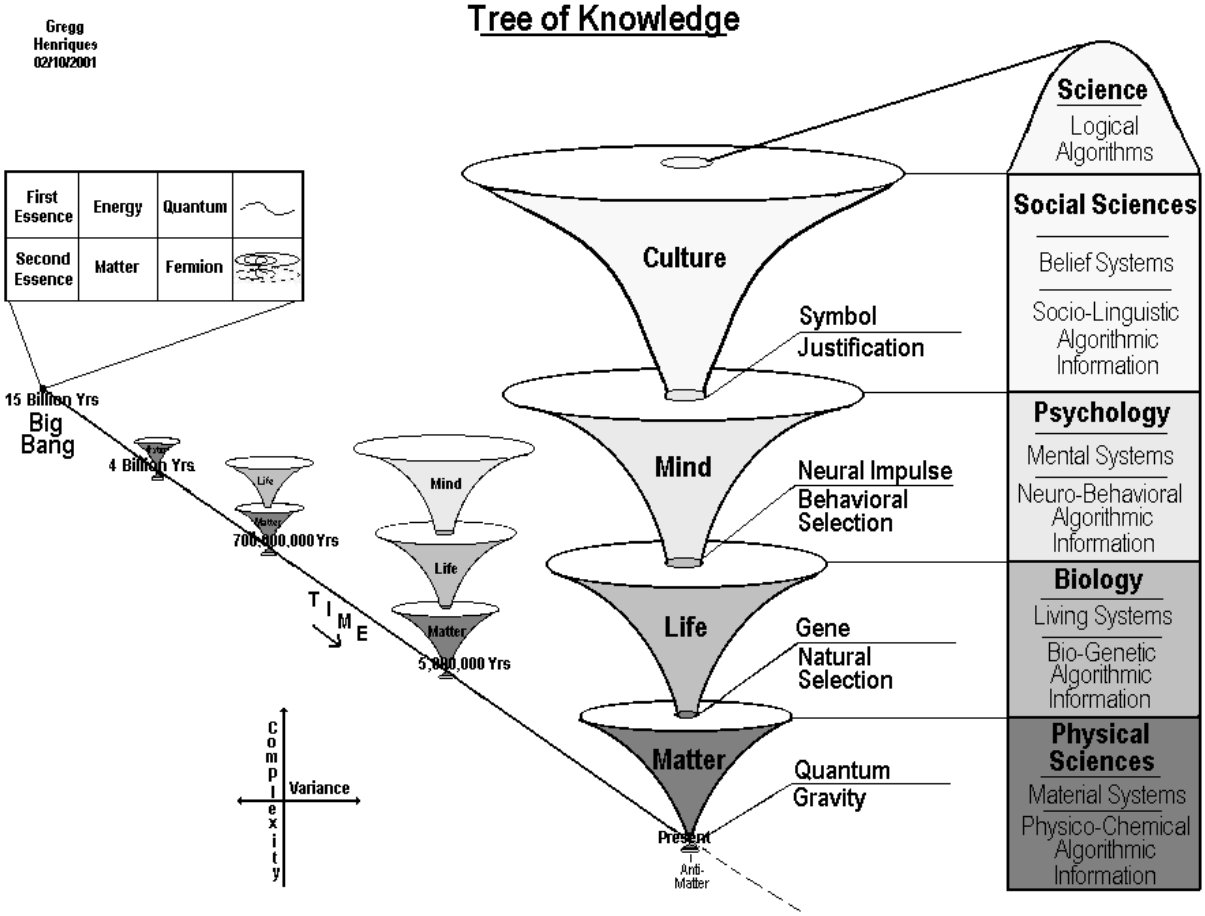
Between approximately 60,000 and 30,000 years ago, there was an explosion of cultural artifacts, such as carved statues, artwork in caves, and burials with ornamentation. Modern humans begin to dominate the landscapes all over the world. And the pace of change only accelerates. Agriculture and writing appear ~10,000 years ago, setting the stage for large scale civilizations and the cultural advances that come with it, such as law, mathematics, philosophy and science. What caused this “explosion” of culture?

The ToK system offers the Justification Hypothesis (JH) as a solution to the problem. The JH proposes that the evolution of language created a fundamentally new adaptive problem our pre-human ancestors had to solve. Language allowed others a window into ones’ thought processes. For the first time, our human ancestors had to explain why they did what they did. That is, they had to justify their actions to others. The JH proposes that problem of justification was the fundamental selection pressure that led to the Modern Human speciation event. The JH argues that the explosion of culture can be thought of as an explosion of justification systems. The JH proposes that the human ego or self-awareness system exhibits the complex functional design consistent with a mechanism designed to solve the problem of justification. That is, humans tend to bias the explanation of their actions to others in a manner that maximizes social influence and minimizes social loss or punishment. The ToK System claims that the evolution of language combined with the JH provides the framework for explaining what differentiates modern humans from other animals. That is, the JH explains why humans have cultures (or shared belief systems that coordinate and legitimize behaviors), why humans have the capacity for reason, and why humans have self-awareness. The JH claims to be consistent with basic observations from Freudian theorists regarding the structure of the Ego, the observations of Social Constructivists who point out the importance of the socio-linguistic environments in dictating what knowledge is legitimate and what is not, and with Social and Personality Psychological findings on the self and social influence.

The ToK system views social institutions such as religion, law, and morality as justification systems. The ToK System further claims that Science is a particular branch in the evolution of justification systems. It is the branch of human belief systems built on the value of accuracy. Scientists seek to generate accurate algorithmic or mathematical representations of change. The ToK System is a proposal for organizing all of Scientific Knowledge. It is a proposal for a Consilient Scientific Mythology of the Universe that stretches from the Big Bang Creation to the Present.

Figure 1

Tree of Knowledge



- This first figure can be considered the primary ToK. There are several things to pay attention to when examining this figure. First, notice that there are four upside down “cones of variance”, Matter, Life, Mind and Culture. Notice that these cones exist on a time-line, which starts at 15 billion years and goes to the present.
    - The cone of Matter is the first cone. The time period from 15 to 4 billion years saw the evolution of atomic and molecular complexities, from the simplest fermions forming at the Big Bang to the self-replicating amino acids which form the chemical building blocks of life.
    - At approximately 3.8 billion years ago, Life emerges out of Matter on planet Earth as a consequence of natural selection operating on self-replicating chemical systems. Natural selection essentially transforms individual self-replicating chemical systems into self-replicating bio-machines that function via genetic information processing.
    - At approximately 640-540 million years ago, the cone of Mind began to emerge. The evolution of the nervous system allowed for the development

of a centralized control center that processed neuro-information and moved the organism as a singularity.

- The cone of Culture began approximately 500,000 years ago, with the earliest emergence of linguistic capacities. As with Life and genetic information processing and Mind and neuro-information processing, the emergence of culture was clearly associated with the development of a new language, symbolic language. The ToK System offers the JH which proposes that the emergence of language created the adaptive problem of justification, which in turn gave rise to the human Ego at the individual level and human culture at the population level.

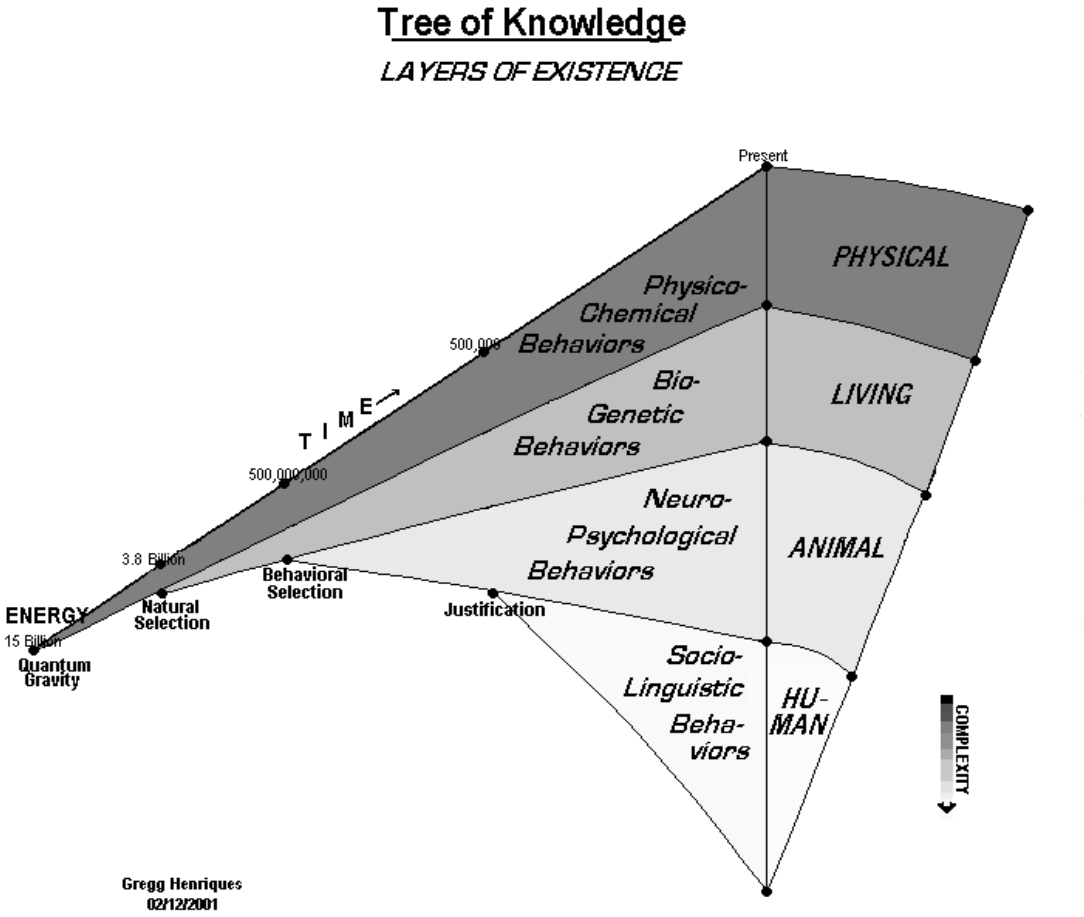
- As Figure 1 illustrates, the ToK System proposes that knowledge can be partitioned into a layer of pure information (Energy Quanta), and four layers of complexity (Matter, Life, Mind and Culture). A key feature of the ToK System is the correspondence between the evolution of these layers of complexity and the organization of the Sciences.

  - The ToK System proposes that Science is a particular type of justification system that emerges out the evolution of Culture. It is a justification system that places value on accuracy. The goal of Science is to develop mathematical representations of change that account for the most amount of variance with the fewest representations. The justification complexity building feedback loop that sparks Culture can be depicted as observe→justify→predict, where justify refers to the linguistic algorithmic representations that organize one's observations. Science emerges as a method of factoring out individual motives which influence the explanatory process in order to leave behind a more accurate representation of change.

  - Ultimately, the Scientific feedback loop that emerges and defines the Scientific branch of justification systems is the measurement→theory→hypothesis feedback loop. This feedback loop is used to develop the equations that map the predictable patterns of energy transfer (behavior).

  - The ToK system proposes there are four fundamental classes of Science, the Physical Sciences, Biological Sciences, Psychological Sciences, and the Social Sciences. These classes of Sciences correspond the behavioral patterns of the different object classes elucidated by the different layers of existence, the inanimate, animate, animal, and human objects.

Figure 2



- This figure offers a slightly different perspective on the Matter, Life, Mind, and Culture "layers of existence" presented in Figure 1. This Figure attempts to capture how these four layers of complexity emerged. This Figure also attempts of capture how simple objects like rocks operate on a single "layer of complexity", objects like plants operate on a double layer of complexity, objects like dogs operate on a triple layer of complexity, and objects like adult humans operate on quadruple layer of complexity.

- The figure attempts to show that each layer is associated with a theoretical process that caused it to emerge.

    - Quantum Gravity refers to the joining of the twin towers in Modern Physics. Quantum Mechanics is the study of the relationship between subatomic

particles and their force interactions. General relativity (the set of equations developed by Einstein to describe the relationship between spacetime and gravity) is used to describe macroscopic change processes in the Universe. The ToK System views Quantum Mechanics as the “specific” Energy-Matter relationship and Relativity as the “general” Energy-Matter relationship. Quantum Gravity refers to the notion that the equations of Quantum Mechanics and the equations of Relativity can be effectively united, so long as important epistemological problems are resolved.

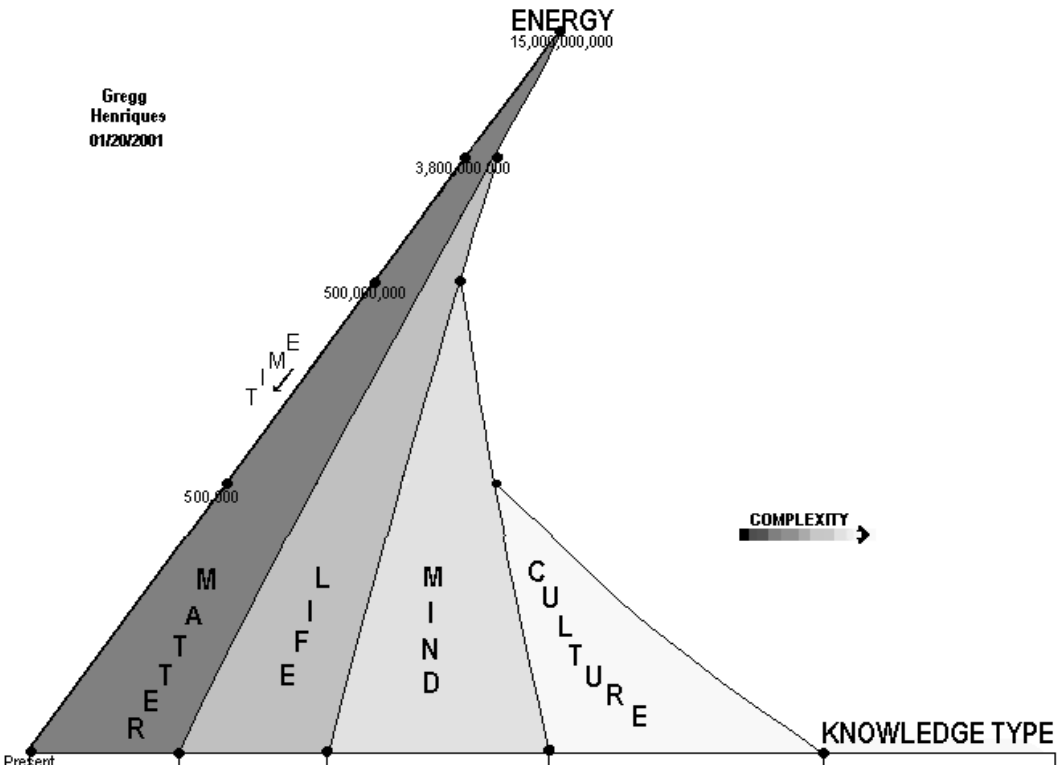
- Natural selection is the process theorized to have transformed self-replicating chemical systems into living cells.

- Behavioral selection is from operant theory and refers to the “observation” of the Behaviorists that the evolution of behavioral complexity over the course of an animal’s lifetime is lawful and can be conceptualized in much the same way as Natural Selection. Certain environmental contingencies select behavioral responses, whereas other environmental contingencies extinguish behavioral responses. Unlike the early Behavioral propositions, the ToK System argues that behavioral selection can only be understood as the process of neuro-information processing and cannot be understood in terms of neuro-mechanical reflexes as early behaviorists assumed. The ToK System also proposes that the term Mind is valid and that the behavior of animals-as-a-whole is not fully reducible to the genetic code.

- As was discussed before, the evolution of language and the problem of justification generated the socio-linguistic layer of information, and is necessary to understand the behavior of Human objects.

Figure 3

Tree of Knowledge



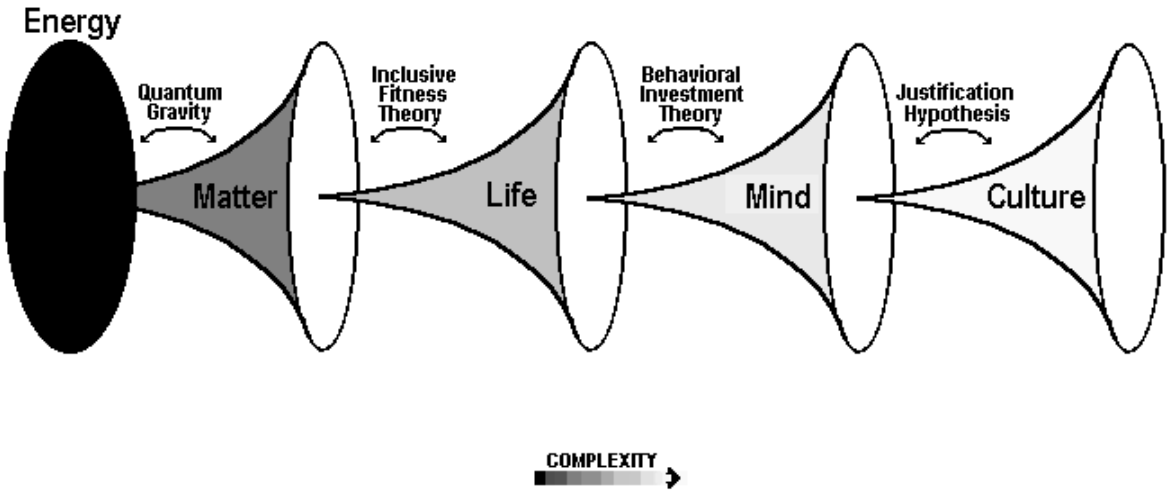
PHYSICS	BIOLOGY	PSYCHOLOGY	SOCIOLOGY	SCIENTIFIC
PHYSICAL INFORMATION SYSTEMS	GENETIC INFORMATION SYSTEMS	NEURONAL INFORMATION SYSTEMS	SYMBOLIC INFORMATION SYSTEMS	SYSTEMATIC
INANIMATE OBJECTS	ANIMATE OBJECTS	ANIMAL OBJECTS	HUMAN OBJECTS	OBJECTIVE
GRAVITATION	NATURAL SELECTION	BEHAVIORAL SELECTION	JUSTIFICATION	PROCESS
ATTRACT-REPEL	ANABOLIC-CATABOLIC	PLEASURE-PAIN	GOOD-EVIL	DIALECTIC
QUANTA	GENE	NEURAL IMPULSE	WORD	COMPUTATIONAL

- Figure 3 is similar depiction of the layers of existence. The focus here is how different types of scientific knowledge map on to the four layers of existence. This organizational symmetry demonstrates the parallels between the four layers. It also provides a framework for organizing much scientific knowledge.

Figure 4

Tree of Knowledge

FIVE ESSENCES LINKED BY FOUR JOINT-POINTS:
A Five Factor Analysis of Variance
Solution to the Problem of Knowlege



Gregg Henriques
02/02/2001

- The ToK System proposes that in the beginning there was a layer of pure information, but no complexity, called Energy. Four layers of complexity, Matter, Life, Mind, and Culture emerged over the course of 15 billion years. These five layers (one of energy information and the other four complexity layers) are considered to be Essences. An Essence is defined by a category of units that are linked by an underlying causal process. We have already discussed how the four layers of complexity are each associated with a fundamental causal process. It may be asked what is the cause of the Energy Singularity? The answer to this question is tautological. Energy causes itself. It is the Uncaused Cause. Although at first glance this appears to be a logical absurdity, it is not. The reasons are two fold. First, causality is intimately connected with time. In fact, time can be considered the direction of causality. Yet, since time does not exist at the level of Energy, the concept of causality within the Energy Singularity looses its meaning. The second reason has to do with the fact that all logical systems must, at their core, be tautological. The mathematician Kurt Godel elucidated this basic truth about logical systems and the ToK is no exception. The reason that logical systems must be tautological is that they must begin with a definitional statement regarding the relationship between variables that cannot itself be proven, but

instead must be considered true by definition. Another way of saying this is that all definitional systems must begin with at least one assumption that cannot be reduced to other assumptions. The ToK assumes that there is something rather than nothing and that that something is Energy, which the most fundamental of all substances.

- With Energy characterized as an Essence, we can state that there are Five Essences linked by Four Theoretical Joint-Points. This Figure attempts to show how the ToK System is proposing a five-factor analysis of variance solution to the problem of objective knowledge.

- Quantum Gravity has been briefly discussed and will be elaborated on further below.

- Inclusive Fitness Theory is a formal name for the modern theory of evolution that explicitly acknowledges that organismic complexity is a function of the replication of genetic material.

- Behavioral Investment Theory (BIT) is a new term and refers to the theoretical amalgamation of several different perspectives on mind and behavior. The essential thrust of BIT is that nervous system evolved as a neuro-computational control center which functions to compute behavioral expenditure of energy in accordance with ancestral inclusive fitness. Behavioral investments that effectively move the animal toward a goal state that positively covaried with ancestral inclusive fitness or move the animal away from a state that negatively covaried with ancestral inclusive fitness are “selected for” and behavioral investments that fail to effectively move the organism are selected against. BIT combines cybernetic, cognitive neuroscience, behavioral, and economic views into a coherent paradigm. Optimal foraging theory and Parental Investment Theory are two theories that are directly consistent with Behavioral Investment Theory.

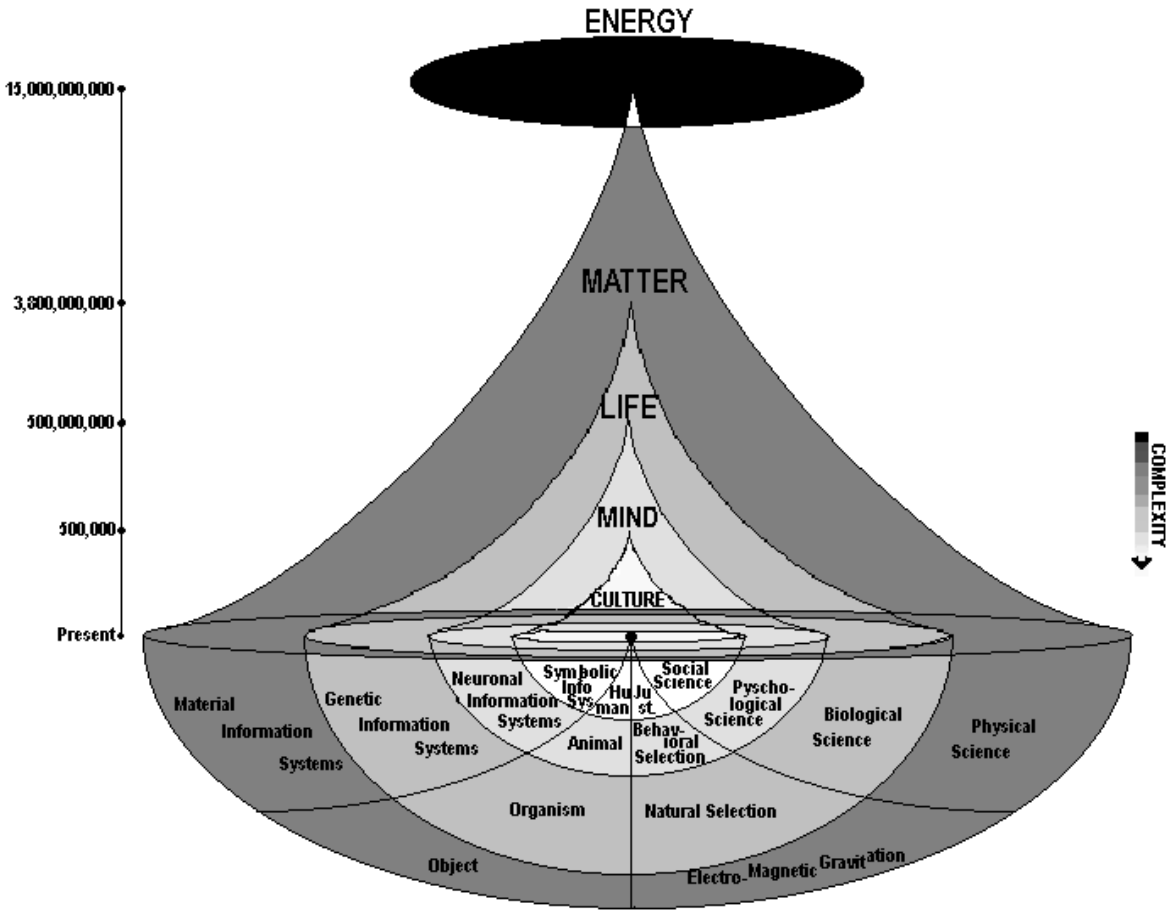
- As was briefly mentioned, the Justification Hypothesis (JH) is a theory of the selection pressure that gave rise to the Ego at the individual level and simultaneously provides a theory of culture at the population level. As such, one way to understand how the Justification Hypothesis solves the Mind to Culture Joint-Point is by understanding how the JH allows for one to theoretically incorporate the Freudian view of the Ego at the level of the individual and the Social Constructivist perspective at the population level. Freud’s fundamental discovery was that there are reasons behind the reasons people give for their behavior. The Freudian Ego (meaning “I”) is the seat of conscious self-awareness. It is a higher order level of functioning than the Id (meaning “it” and referring to animalistic impulses of sex and aggression) and functions to serve as a filter for the Id impulses, so that the impulses are expressed in a way that is justifiable. He had further discovered that the Ego could be thought of as a rationalizer (read justifier in the ToK system) of underlying motives. Freud’s

conception of the ID was wrong, but Social and Personality Psychology have demonstrated that he got the Ego correct.

A fundamental prediction of the JH is that humans will explain their behavior in accordance with ancestral inclusive fitness. The JH claims that to do this, human justifications about the self should be biased in a manner that maximizes social influence. The JH claims that the major findings in cognitive, social, and personality psychology, such as organization of self-schema and self-related memories, cognitive dissonance, the self-serving bias, attribution errors and tendencies, the “interpreter” function of the left hemisphere as has been elucidated by studying patients with a severed corpus collosum, differences in deotnic versus analytic reasoning, and the Freudian defense mechanisms of suppression, repression, denial, rationalization, moralization, reaction formation, and sublimation can all be usefully understood as representing aspects of a Human Ego or Self-Awareness System that functions to allow individuals to justify their actions in a manner that maximizes social reward and minimizes social punishment. A key prediction of the JH that can be readily tested is that humans should justify their actions in accordance with ancestral inclusive fitness. That is, they should have a genetic self-serving bias.

Social Constructivism is the dominant paradigm of the social sciences. Simply stated, social constructivism is the position that human knowledge is dependent on the socio-linguistic context in which it exists. Right and wrong are relativistic concepts that depend on the human belief system that they exist in. Culture is thought of as the shared belief systems that coordinate the actions of human individuals. Social scientists emphatically, and correctly according to the ToK system, argue that Human behavior can only be thought of in terms of the wider belief system it is emerged in. The socio-linguistic belief systems that coordinate human action are referred to as Justification Systems in the ToK definitional system. Justification systems refer to the interlocking set of linguistic representations that legitimize certain behaviors and prohibit others. Religion, morality, law and science are readily conceptualized as justification systems.

Figure 5



- A major epistemological problem that faces Science is the issue of reductionism. Are the various levels of complexity fully reducible to the levels beneath them? The ToK System proposes a hierarchical organization of complexity via the process of algorithmic layering. Different layers of complexity emerge because of a complexity building feedback loop that gives rise to a new computational level. The emergent nature of these layers argues against an extremist reductionistic stance. On the other hand, it should be equally clear that the higher layers of complexity exist within the lower layers. Although it may seem as though it is a logical contradiction to suggest higher layers of complexity exist both within and on top of the lower layers, it is not. Figure 5, particularly in conjunction with Figure 1, shows how this conception is reasonable.

- Figure 5 also includes an equation that represents the Godelian tautology that starts the ToK System. A version of the same tautology was mentioned earlier in the context of defining Energy as an Essence. The tautological equation is expressed as the following algorithmic representation:

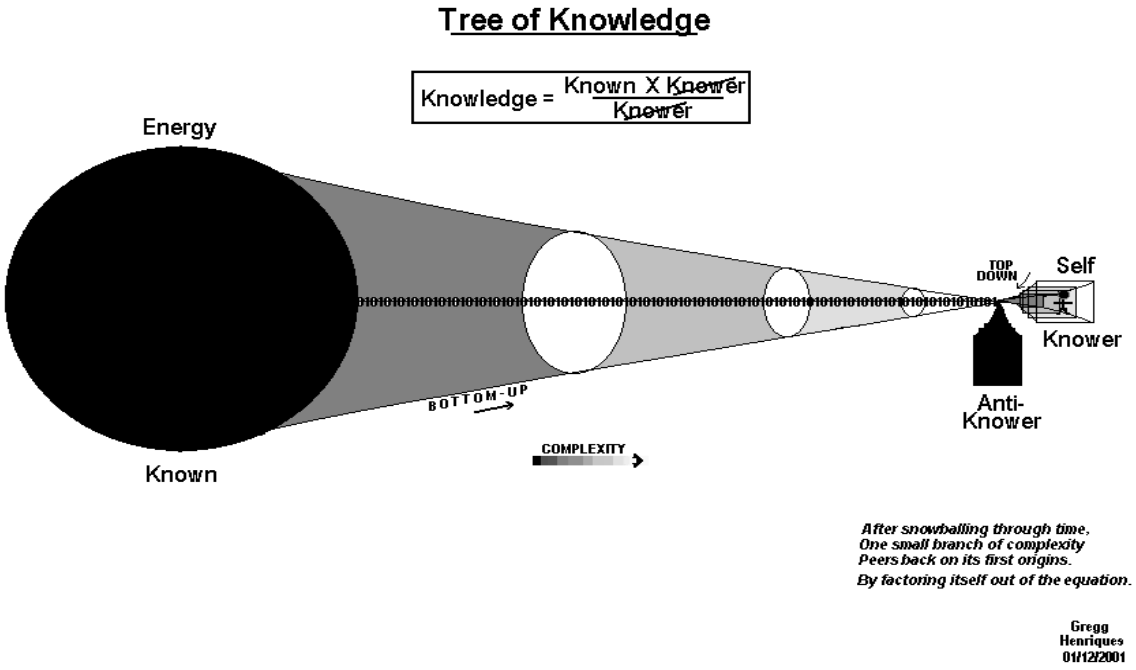
$$\mathbf{1 \bullet Bang = \infty_r \bullet q}$$

where **Bang** refers to the Energy Singularity at the beginning of the Universe, ∞r refers to "real infinity" and **q** stands for Quantum. Stated simply, the equation reads one Bang equals real infinity times the number of individual quanta. It is useful to retranslate the equation to see it for the tautology that it is. A quantum is the absolute smallest irreducible unit of energy. Bang is the absolute largest energy quantity. One represents the absolute smallest irreducible digit. "Real Infinity" represents the absolute largest amount. Once retranslated the equation reads:

(Absolute Smallest)(Absolute Largest) =
(Absolute Largest)(Absolute Smallest)

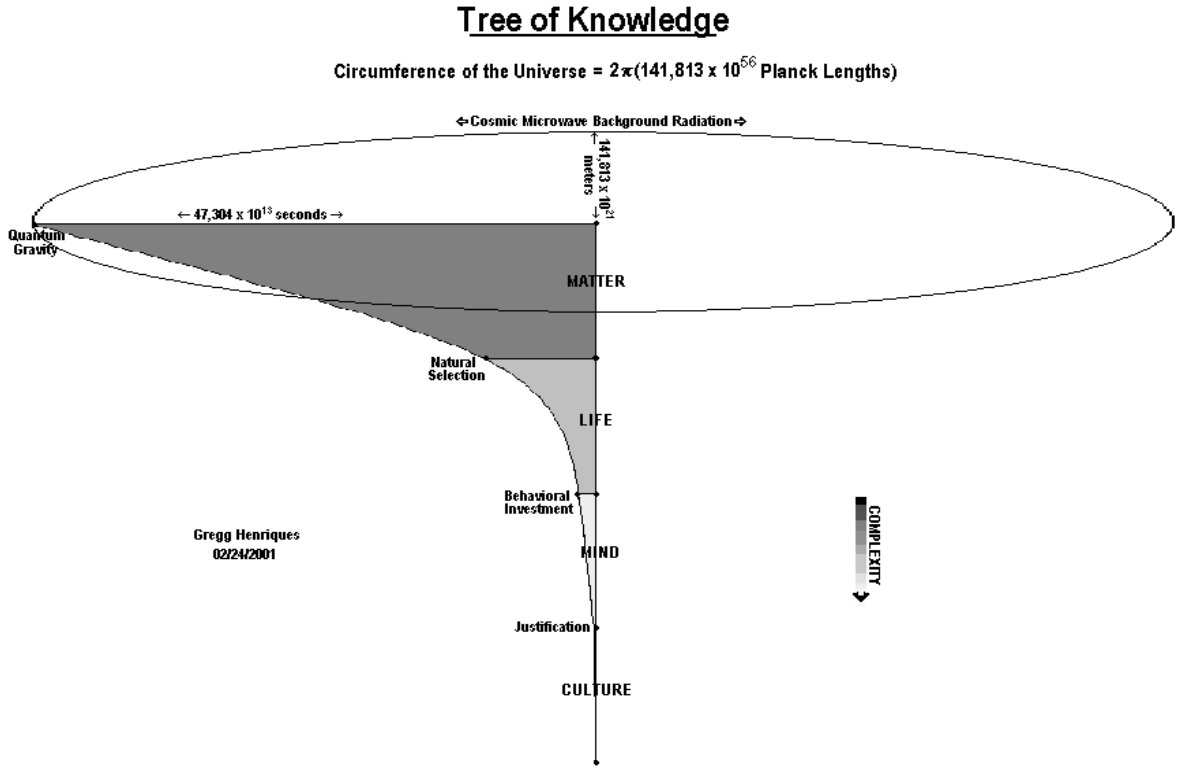
This in turn represents a tautological equation that cannot be proven to be true, but instead can only be said to be true by definition.

Figure 6



- The ToK System offers an entirely new way of looking at the nature of knowledge and the relationship between knower and known. This Figure attempts to capture how the ToK System allows knowers to simultaneously view knowledge from a bottom-up and top-down perspective. This simultaneous view allows for the knower to be "factored out" of the equation, leaving behind an accurate algorithmic representation of change.

Figure 7

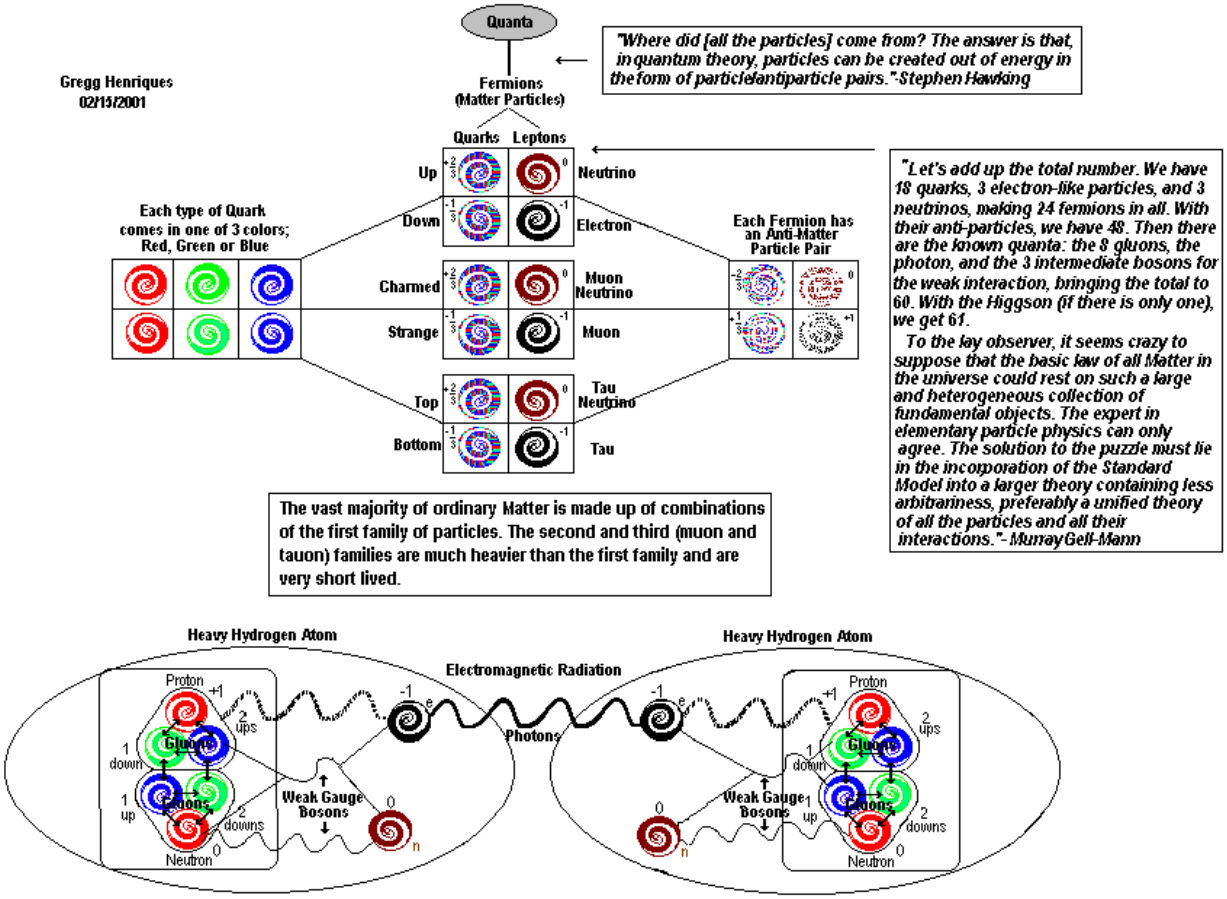


- Figure 8 provides a Time x Space x Complexity representation of the ToK System. This representation demonstrates the accelerating nature of the evolution of complexity and shows how the evolutions of Mind and Culture have taken only a very small fraction of the entire span of the Universe's existence.

- The diagram also includes a depiction of the Cosmic Microwave Background Radiation. CMBR is the radiation released by the Big Bang Explosion. It consists of photons moving away from the Big Bang at the speed of light. As such, one can calculate the radius of the universe by calculating the distant such photons have traveled.

Figure A

The Standard Model in Elementary Particle Physics



- Figure characterizes the Standard Model in Elementary Particle Physics in such a way as to demonstrate that the Standard Model is consistent with the ToK conception. A fundamental component of the ToK System is the notion that Matter emerged out of Energy. Figure 5 of the ToK System provides a representation of the general relationship between Matter and Energy. In order to understand the specific Energy-Matter relationship, it is important to understand the Organization of the Standard Model. According to the Standard Model, all Matter is made up of fermions. Fermions are different than Energy Quanta in that they obey the Pauli Exclusion Principle, which states that two fermions cannot occupy precisely the same quantum state. Quanta, which are bosons, do not obey the Pauli Exclusion Principle.

- The quote from Stephen Hawking's *A Brief History of Time (2nd Edition, p.133)* demonstrates that quanta are theorized to give rise to fermions.

- Murray Gell-Mann won the Nobel Prize in Physics for his discovery of the Quark. His quote is taken from *The Quark and the Jaguar, p.197* (1994) and provides a nice summary of the Standard Model. The quote also demonstrates that the Standard Model is incomplete and needs to be incorporated into a larger system. The ToK proposes to be the outline of just such a system.

- The diagram of the Heavy Hydrogen Atoms at the bottom provide a representation of how the quarks combine to make protons and neutrons and how the various force interactions occur.