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AN INTRODUCTION TO CONSCIOUS EVOLUTION:
A THEORY WE CAN THRIVE WITH



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HUMAN CIVILIZATION IS AT AN EVOLUTIONARY crossroads where unsustainable human behaviour is precipitating the planet's 6th Mass Extinction Event[1]. Five times in Earth's history, life was thriving when some event precipitated a wave of extinction, eliminating 70 to 90 percent of all plant and animal species. The last mass extinction event, 66 million years ago, noted for wiping out the dinosaurs, was apparently due to a massive asteroid impact in Mexico that upended the global web of life. Today's severe environmental imbalance is, in large part, attributable to the cultural consequences of Darwinian evolution theory, which holds that struggle and competition are the driving forces behind evolution. But the Darwinian notion that evolution is driven by the survival of the fittest in a continual competition among individuals is giving way to a more scientifically accurate, as well as, more positive theory of evolution that emphasizes the role of cooperation, interaction, and mutual dependence among all life forms. In the words of Lynn Margulis, "Life did not take over the globe by combat, but by networking"[2].

The once universally accepted Darwinian theory about the origin and evolution of life emphasized a two-step process to account for evolution. First, random variations in hereditary traits, introduced during reproduction, provide offspring with physical and/or behavioural characteristics that differ from those of their parents. Second, the fate of "altered" individuals, specifically their ability to survive and pass on their "new" traits to the next generation, is determined by natural selection, a process often abbreviated as the "survival of the fittest in the struggle for life." From this perspective, violence and war are considered to be natural behaviours in determining the "fitness" of our species. Evolution results from a continuous lineage of species expressing ever-increasing structural and behavioural complexity.

Ernst Haeckel famously illustrated the Darwinian progressive lineage of species evolution in his 1879 image of the Tree of Life. Primitive bacteria were positioned at the Tree's base, while human beings, perceived as the most advanced species, were placed at the Tree's top branches (FIGURE 1 NEXT PAGE)[3].

At the time Haeckel conceived of the Tree, there was no scientific insight about the nature of the hereditary mechanisms responsible for the evolution of the depicted species lineage. More than a decade earlier, Catholic monk Gregor Mendel's experiments with crossbreeding pea plants between1856 and 1863 had introduced the concept of "genes," though it was Danish botanist Wilhelm Johannsen who first introduced the term gene in 1909. Mendel's seminal research, which founded the modern science of Genetics, languished in obscurity for over three decades before it was resurrected in 1900 by botanist Hugo de Vries, whose own breeding experiments verified Mendel's conclusions.

Two years after Mendel's work resurfaced, research by cytologist Theodor Boveri connected Mendel's concept of genes with the function of chromosomes, thread-like structures observed in the cell's cytoplasm. Boveri's experiments manipulating chromosomes as well as his observations of chromosomes in normal and cancer cells, led him to conclude that chromosomes are the physical units of heredity alluded to

in Mendel's research. In an effort to understand the true nature of a "gene," chromosomes were chemically deconstructed and found to be comprised of 50% protein and 50% DNA. The question as to which of these macromolecules provided the trait-controlling genes was resolved in 1944 with Avery, MacLeod, and McCarty's research that included two morphologically distinct species of pneumococcal bacteria[4]. When incubating bacterial species R in a DNA extract from the chromosomes of species S, the R bacteria acquired species S traits. In contrast, extracts of species S chromosomal proteins were unable to transfer S traits to species R bacteria. The results firmly established that DNA molecules are the carriers of genetic information.

The next step toward understanding evolution was to assess the nature of DNA's molecular structure in order to gain insight into the mechanics of heredity. X-ray crystallography studies of DNA molecules by Rosalind Franklin in 1952 led to the discovery of DNA's double helix structure. Without her knowledge, Maurice Wilkins, a disgruntled colleague of Franklin, gave her unpublished crystallography data to James Watson and Francis Crick. Using Franklin's data, Watson and Crick changed the course of human history when their article, "Molecular Structure of Nucleic Acids" was published in the prestigious British scientific journal *Nature* in April of 1953[5]. In their paper, Watson and Crick revealed how the sequence of nucleic acid bases (adenine, thymine, cytosine and guanine) along the DNA molecule programs the structure of proteins, the macromolecules that provide for an organism's anatomy and physiology.

The next challenge was to discover the mechanism that controlled the synthesis of DNA. Matthew Meselson and Franklin Stahl revealed the surprising answer to that quest in 1958 when they separated the two strands comprising a DNA double helix molecule and incubated each single DNA strand in a solution containing the four nucleic acid bases that comprise the molecular building blocks of DNA. Each DNA strand served as template for the synthesis of its complementary new strand. During cell reproduction, the DNA double helices split apart with each separated DNA strand serving as a pattern for recreating the double helix. The "obvious" conclusion was that DNA controls its own reproduction.

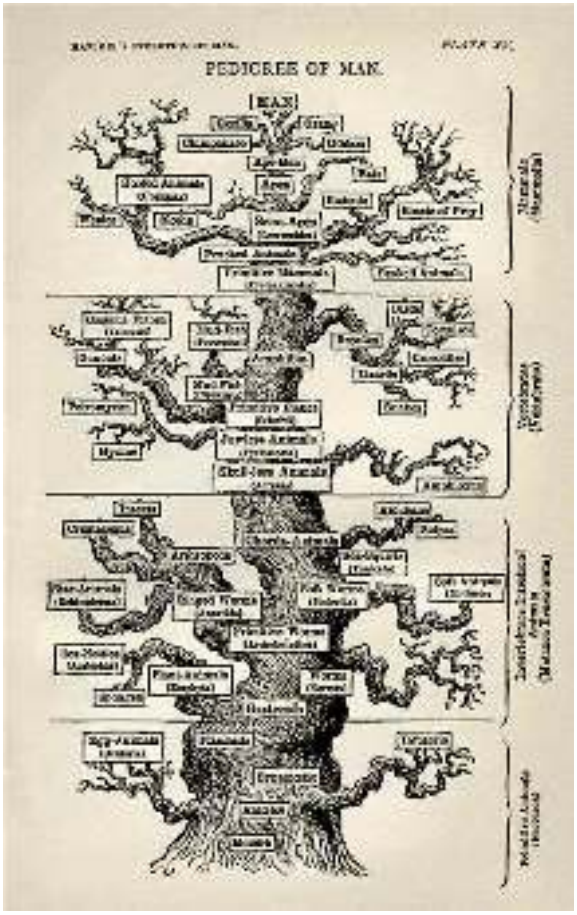


FIGURE 1 ~ *Haeckel's Tree of Life.*

In the wake of the Meselson-Stahl experiment, Crick published a hypothesis defining the flow of information in biology along a unidirectional path from DNA▷RNA▷protein, a chain of command predicated on DNA's autonomous, self-controlling mechanism[6]. Crick's hypothesis led to the belief that genes are self-actualizing, i.e. they turn themselves on and off and thereby represent the sole control of the hereditary characters that shape an organism. This notion of genetic control implied that people had no influence over their genetic fates but instead is "victims" of their heredity. For example, a history of a recurrent pathology in the family lineage, such as cancer, heart disease, or Alzheimer's, implied that children in that family would possess the disease-causing genes and should expect to experience the same fate as their parents.

Crick's theory also emphasized that an accidental alteration in the genetic code, introduced through copying errors in the process of DNA replication, is the initiating factor for evolution. Crick's hypothesis, which he referred to as *The Central Dogma*, became the foundational principle that shaped the next 50 years of biomedical research. It's a disturbing principle because the *Dogma* emphasized that evolution

is independent of environmental circumstances. The emphasis on DNA's primacy in controlling life led to the Human Genome Project, an effort to identify all the trait-controlling genes found in the human genome. Armed with such knowledge, it was thought that genetic engineering would enable humans to control their fate, as well as offer science the ability to create "new" organisms, in what would amount to human-designed evolution.

But by the time the Human Genome Project got off the ground in 1990, research was undermining the conclusions of Crick's *Central Dogma*, which, after all, was only a theory he introduced to the public around 1960, though the premise was repeated so frequently over decades that people forgot it was only a hypothesis and assumed it was scientific "truth."

1 - The Dogma's unidirectional flow of information was upended by Harold Temin's Nobel Prize-winning research on reverse transcriptase, the enzyme infamous for its role in the propagation of the AIDS virus[7]. Temin's research changed the Dogma's information flow by showing that RNA can alter the information coded in DNA: DNAÛRNAÞprotein. Temin's research was included in Crick's formal journal article in 1970[6].

2 - Cell replication research that factored in the role of the formerly discarded chromosomal proteins also changed the understanding of information flow in biology. This research found that DNA does not control its own activity, but is dependent upon the activity of chromosomal proteins that are controlled by environmental signals. As succinctly stated by Nijhout in 1990, "When a gene product (i.e., protein) is needed, a signal from its environment, not an emergent property of the gene itself, activates[7] expression of that gene"[8].

The *Dogma's* latest information flow chart reads as: DNAÛRNAÛprotein.

Then came the 2003 results of the Human Genome Project, which further eroded belief in Crick's Dogma. Science had held that the evolutionary lineage illustrated in the Tree of Life represented a hierarchy of species with ever increasing genetic complexity. Simple organisms near the base of the Tree would possess a small number of genes, and as one ascended the Tree, more advanced organisms would have greater numbers of genes to accommodate their more complex structural and behavioural traits.

Based on the belief that every protein required a gene blueprint for its synthesis, scientists estimated that the human genome would have a minimum of over a 100,000 genes. But the project found instead that despite humans' lofty position on the Tree, the human genome contains only ~20,000 genes[9]. That result upended the fundamental tenet of modern genetics that one gene codes for one protein. But there was more. It turned out that the miniature roundworm, *Caenorhabditis elegans*, an organism at the bottom of the Tree comprised of only 1,031 cells, has the same number of genes as humans at the top of the Tree comprised of 50 trillion cells, which led to the project's most profound insight: evolutionary lineage does not reflect increased genetic complexity.

These new insights profoundly revised the foundation of genetics and led to the formalization of a new field of heredity research, *Epigenetics*. In contrast to the conventional belief of genetic control (i.e., "control by genes"), the prefix "epi" in the term epigenetic control, simply translates as, "control *above* the genes." It is now recognized that the environment, and especially our perception of the environment, provides the source of "control" above the genes and represents the primary factor that shapes genetic activity. Epigenetic mechanisms can create thousands of different variations of proteins from a single gene blueprint[10].

The new emphasis on the role of the environment in controlling heredity resurrected Jean Baptiste Lamarck's once ridiculed theory of evolution. Published fifty years before Darwin's *Origin of Species* in 1809, Lamarck's theory of evolution scored the hierarchy of species in the lineage on the basis of their level of consciousness rather than their level of genetic complexity[11]. Unfortunately, the definition of the term "consciousness," has itself been a source of problems — some definitions of consciousness are philosophically based and take pages to define. At the simplest level of understanding, consciousness can be described as the state of "being awake and aware of one's surroundings." Using this definition, more than two centuries after Lamarck, Margulis successfully argued that primitive single-celled organisms, from bacteria (prokaryotes) to amoebas (eukaryotes), clearly possess a primitive level of consciousness[12].

Still, efforts to assess the nature of consciousness and the nervous system's role in evolution have been thwarted by the unimaginable complexity of the connectivity and information flow in the brains of higher organisms, which can contain a trillion or more cells. Recent research has focused on a lower organism, the microscopic brain of *Caenorhabditis*. Histological studies of this worm's brain have provided a complete "connectome," a map revealing all the connections among the brain's 302 cells. Despite this mapping information, the complexity of the information flow has made it impossible to decipher how the brain creates the character of "consciousness," and specifically, how that consciousness would influence evolution.

A different approach to understanding the role of the nervous system is to study single-celled organisms, such as amoeba. Protozoan eukaryotic (nucleus-containing) cells have the same physiologic systems found in human beings that control respiration, digestion, excretion, musculoskeleton, endocrine and immune functions, and most important for this story, a nervous system[13]. In the single-celled species, cytoplasmic miniature organs ("organelles") provide the same physiologic functions that in humans are provided by the complex organs. As to the question of which of these organelles serves as the "brain" of single-celled species, current biological curricula still point to the nucleus. But that "fact" has been challenged by enucleation research, in which micropipettes are used to remove the cell's gene-containing nucleus. Though these cells have virtually no DNA, they can survive for weeks and still exhibit complex behaviours. The only function lost in enucleated cells is the ability to reproduce their proteins and even the cells themselves. This research suggests that the nucleus is not the "brain" of the cell, but in reality, represents the cell's "gonad."

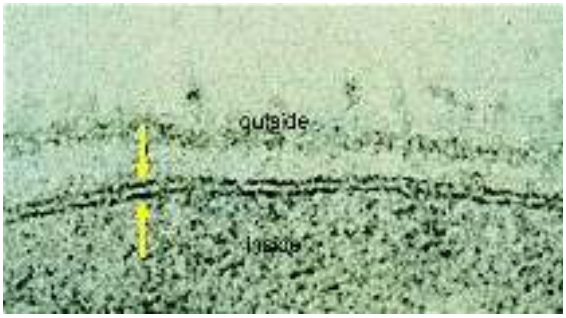


FIGURE 2 - *Electron microscopic image of cell membrane (between arrows), cytoplasm is below the membrane.*

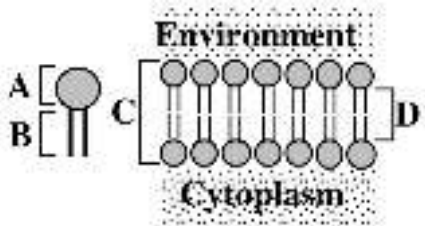


FIGURE 3 - *Molecular model of crystalline phospholipid bilayer forming cell membrane.*

My research on cloned stem cells during the late 1960s and early 70s also provided insight into the nature of the cell's brain[14]. This research involved inoculating a culture dish with a single multipotential stem cell. Cultured stem cells divide every 10 to 12 hours; one week after plating a single stem cell, the culture contains approximately 24,000 cells. All the cells in the culture dish are genetically identical because they are progeny of a single parent cell. I split up the cell population into three dishes, each with different culture mediums, i.e. each with a different environment. In environment A, the cells formed muscle. In environment B, the cells formed bone and in the third environment C, the cells formed fat cells. Because all the cells were genetically identical, the results revealed that the fate of cells is controlled by their response to the environment and not by their genes. These original observations illuminated the role of epigenetics 20 years before this field of knowledge was officially recognized.

The results of these cell culture experiments as well as enucleation experiments, shifted attention to identifying the cellular equivalent of the human nervous system responsible for translating environmental signals into cell behaviour. That search led to the bacterial cell membrane, the cell's only structured organelle. With a thickness of 10 nanometers, the physical dimension of the cell membrane is well below the resolution of the light microscope. In fact, scientists only learned that all cells possess a cell membrane when the electron microscope was invented in the late 1940s. In electron micrographs, the cell membrane appears as a vanishingly thin (<10nm), tri-layered (black-white-black) "skin" enveloping the cell (FIGURE 2).

A general rule in biology is that structure implies function; simple structures have simple functions and complex structures express complex functions. But cell membranes are the exception to that rule. While simple in structure, the cell membrane, which was the first biological organelle to evolve, is far from simple in function. Membranes provide a physical barrier separating the interior cytoplasmic domain from the external environment, but they are also responsible for respiration, digestion, and excretion functions, and serve as each cell's "nervous system" because of their ability to "read" external environmental conditions and then relay regulatory signals internally to control cytoplasmic behaviour.

As for the structure of the membrane, its layered appearance in the electron microscope directly reflects the molecular organization of its phospholipid building blocks. Lollipop-shaped phospholipid molecules are amphipathic, possessing both a globular polar phosphate head (FIGURE 3a) and two stick-like non-polar legs (FIGURE 3b). When shaken in solution, phospholipid molecules self-assemble into a stabilizing crystalline bilayer (FIGURE 3c). The illustrated membrane model clearly reveals the reason for the dark-light-dark layering observed in the microscope.

The molecule's lipid legs, forming the membrane's central core, provide a hydrophobic barrier (FIGURE 3d) that physically partitions the cytoplasm from the external environment. While cytoplasmic integrity is maintained by the lipid's passive barrier function, life processes necessitate the active exchange of metabolites and information between the cell's cytoplasm and surrounding environment. A membrane comprised of only phospholipids would not support the transport activities required to sustain life.

Enter the crucial cell membrane's large population of proteins (100,000+) that are unseen in electron microscope images. Because these proteins are physically integrated within the membrane's structure, they are referred to as integral membrane proteins (IMPs). There are two fundamental roles attributed to all cellular proteins.

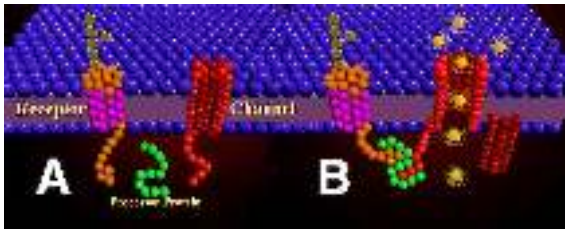


FIGURE 4 ~ *Receptor-Effector IMP switch in membrane. (A) Inactive "switch" on left signal; (B) after signal coupling, activation leads to conformational changes which couple receptor with channel. The channel protein's wall is cut open to reveal signal ions transiting pore.*

1 ~ They provide for the cell's physical structure (anatomy).

2 ~ They are responsible for generating the cell's vital physiologic functions.

To understand how membrane proteins perform those roles, it is necessary to consider their shape-shifting structure. Each protein's unique 3-dimensional structure is defined by its "backbone," a linear molecule comprised of a specific sequence of amino acid molecules strung together like beads on a string. After the amino acid backbone is assembled during protein synthesis, it spontaneously folds into a specific three-dimensional conformation (shape) by balancing the electrical charges within its amino acid backbone. A protein molecule responds to an environmental signal, such as an ion, a molecule, or resonant vibrational field by shifting into a complementary physical shape. The binding of an environmental signal to a protein, alters the distribution of electric charges along the protein's backbone. In response, the protein's shape is reconfigured as its backbone adjusts by folding to accommodate the altered electrical charges. Simply, when a protein binds with a complementary environmental signal, it causes the protein to shift from conformation A to conformation B. The movement generated by protein conformational changes is harnessed by the cell to power its physiologic behaviours.

Membrane IMPs can be functionally subdivided into two major populations: receptors and effectors. Receptor proteins are molecular "antennas" that recognize environmental signals; effector proteins are output devices whose function is to regulate cellular processes (FIGURE 4). Membranes have thousands of different types of receptors, each responding to a specific environmental signal. Bonding with an environmental signal induces a change in the receptor protein's shape from its resting (inactive) conformation to an "activated" conformation. The activated receptor conformation enables it to bond with either a specific function-producing effector protein or with an intermediary processor protein. Receptor proteins return to their "inactive" conformation and detach from effector proteins when the prevailing signal ceases. Like receptors, effector proteins generally display at least two conformations: an active configuration in which the protein expresses its function and a "resting" conformation in which the protein is inactive. These observations reveal the cell membrane to be an organic information processor whose receptor-effector IMP complexes are molecular "switches" connecting specific environmental stimuli with specific behavioural responses.

The membrane's information processor function becomes more evident when defining its structural and functional characteristics. First, the molecular order of the phospholipids in the membrane defines it as a crystal. More specifically, the membrane's flexibility reveals that its lipid bilayer is actually a liquid crystal. The membrane is an impermeable barrier because its hydrophobic lipid core prevents the trans-membrane flow of water-soluble ions and molecules, which gives it the character of a nonconductor. A significant modification in the membrane's definition is provided when IMP functions are taken into consideration. Receptor proteins relay specific environmental signals to engage specific outputs, which makes the term "gate" the perfect synonym for receptor functioning. Effector IMP s, specifically channel proteins, provide selective permeability across the membrane's lipid barrier. A membrane made of only phospholipids would be a nonconductor, but the introduction of protein channels gives it the property of being a conductor. In consideration of the selective nature of what channels transport, the membrane is actually a

semiconductor. When factoring in the membrane's structural and functional characteristics, the definition reads: *The membrane is a liquid crystal, semi-conductor with gates and channels.*

The exact same terminology defines the character of a silicon computer chip, though it is of profound importance to emphasize this is not a coincidence because the cell membrane is a homologue, not an analogue, of a computer chip. The functional components that contribute to the information processing behavior in a silicon chip have their exact counterparts in the carbon-based cell membrane. Cornell and others verified the cell membrane behaved as a biological "chip" in studies of cell membranes bound to gold foil electrodes. By monitoring the flow of electrolytes between the membrane and the foil substrate, researchers were able to record a digit readout of the opening and closing of the membrane's receptor-activated ion channels[15].

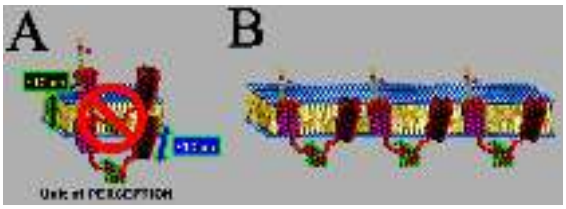


FIGURE 5 - *In (A), size restrictions prevent receptor-effector proteins from stacking upon one another. In (B), new perception units can only be added laterally, forming a monolayer.*

The complex functions of the cell membrane described above demolish an old belief, and for far too many, a currently held belief, that gene "programs" in the nucleus represent read-only memory (ROM), a belief predicated on the information flow described in *The Central Dogma*, DNAÞRNAÞprotein. Crick's *Central Dogma* gave rise to the concept of genetic determinism, the belief that our fate is preprogrammed in our genomes. Since the human body represents the protein in Crick's information flow, it was assumed that we are powerless in influencing our genes. Hence the presumption we are "victims" of our heredity. As is evident from studies on membranes in single-celled species, the character of human consciousness did not arise intact out of thin air. Instead, it evolved as a gradient of expression ranging from the primitive awareness of a bacterium to the self-consciousness of Albert Einstein.

In fact, the level of consciousness expressed by an organism can be directly attributed to the number of receptor-effector switches (units of perception) its membrane possesses. In recognition of the membrane's homology with a computer, receptor proteins function as Inputs (I), while effector proteins are Output (O) devices. Defined as an I/O makes a receptor-effector complex technically a BIT of data. As with any information processor, the membrane's processing power is scored by the number of BITs it handles.

Consequently, the processing power expressed in terms of an organism's consciousness can be mathematically quantified by calculating the number of perception proteins (BITs) it possesses. The thickness of the cell membrane is fixed at ~10 nanometers due to the dimensions of the phospholipid molecules comprising the bilayer. Because of the structural limitations imposed by the lipid bilayer's dimension, IMPs cannot be stacked – they can only be deployed as a monolayer.

These structural limitations have far-reaching consequences. The population of consciousness-providing perception units (BITs) is directly proportional to membrane surface area, consequently the evolution of consciousness can be mathematically modeled by mapping an organism's membrane surface area[16]. Modelling membrane evolution necessitates the use of fractal geometry, since the repetitive branching-within-branching structure of a fractal represents the best way to get the most surface area within a three-dimensional space[17]. The fractal character of the membrane's geometry facilitates an understanding of evolution of consciousness because fractal structures are built from iterated, self-similar patterns present at every level of the organization.

The external rigid capsule of the primal prokaryote cells represented a structural parameter that imposed limits on the physical amount of membrane surface area that can be contained within a single cell. After the appearance of primitive bacteria-like prokaryote cells 4 billion years ago, Phase 1 of evolution focused on making the "smartest" cell by maximizing the prokaryote's membrane surface area and IMP population. Once the prokaryote acquired its full complement of membranes, evolution stopped. Subsequent advancement in evolution employed a different paradigm. In phase 2, rather than focusing on enhancing the consciousness of the individual cell, evolution advanced by assembling individual cells together to form community. Communal organizations contributed two additional survival advantages over the evolution of the single cell.

1 - Enhanced Awareness: An organism's survival is based upon its level of awareness, which is directly proportional to its membrane surface area. Evolution's Phase 1 maximized the information-handling

awareness of the individual cell. Once completed, the only way it could acquire more awareness was to couple with other cells in community and share awareness. Community provides more "eyes" to see the world.

2 - Increased Efficiency: The division of labour among cells in a community offered an additional survival advantage. Consider the old adage, "Two can live as cheaply as one."

To survive, each cell is required to expend a certain amount of energy. The amount of energy conserved by individuals living in a community contributes to both an increased survival advantage and a better quality of life. Initially, bacterial cells lived in widely dispersed communities, wherein individual cells were physically scattered throughout the environment. Over time, heterogeneous groups of bacteria assembled into physically close-knit communities. To protect themselves from the ravages of harsh and extreme environments, these prokaryote communities secreted polymers aka biofilms that provided a protective, yet permeable membrane-like barrier. The earliest biofilm fossils are dated at 3.5 billion years old. Their evolutionary success is illustrated by the fact that they currently represent more than half of the earth's biomass. The first communities on the planet are still the most dominant communal organization on Earth[18]. Many biologists believe that the transformation of primitive biofilm communities into single-celled eukaryotes, just over 2 billion years ago, represented one of the most significant events in the history of life on Earth.

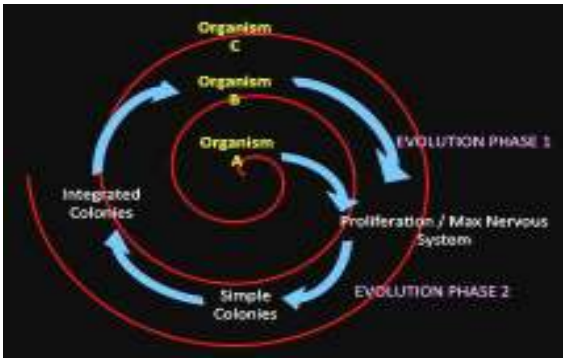


FIGURE 6 - *Spiral progression of evolution is cyclic. In the first cycle, a new organism A, once formed, enters Phase 1 through which the development of its nervous system becomes fully maxed out. When complete, evolution switches to Phase 2 wherein individuals assemble to create community. Phase 2 of the cycle ends when, highly structured, efficient colonies can transform into a new organism, Organism B. The next cycle begins when the evolved organism B uses the Phase 1 paradigm to maximizes its awareness. Currently, life is in nearing the end of the third cycle that was initiated when primates evolve as Organism C.*

While the evolutionary success of biofilms is a testament to the enhanced survival value of sharing awareness, the benefits of communal living come at the high cost of supplying the energetic needs to support the livelihood of 10 thousand or more communal cells. Evolution resolved those high maintenance costs by transforming the multicellular community into a eukaryote (nucleus-containing) cell, a new form of life form. This observation led to the fascinating question of how it happened, i.e., "How did the genetic traits derived from a multitude of prokaryote precursors end up in a single cell?"

Margulis theorized that larger, more advanced eukaryote (nucleus-containing) cells were derived from microbial colonies and that symbiosis, which is the assembly of individuals based on mutually beneficial relationships, was the major drive force behind evolution[19]. Recent genome research reveals that genes can be *shared* among members of different species via a mechanism referred to as gene transfer[20]. This is Nature's method of enhancing the survival of the communal biosphere because organisms can rapidly acquire behavioural programs and traits from other organisms.

The gene transfer process also enabled vital gene programs from individual cells comprising the biofilm to be collectively localized within a single membranous repository, the precursor of the cell nucleus. Centralizing the gene programs precluded the need to maintain a massive prokaryote population within the film. Eventually, eukaryotic physiologic functions, derived from the behaviours of former communal microbial cells, were taken over by specialized, non-living cytoplasmic organelles.

Thus the origin of eukaryotes as a "new" organism initiated a new cycle of Phase 1 and Phase 2 evolution. With the development of a supporting internal cytoskeleton, eukaryote cells were able to significantly increase their size (50 to 100 microns in diameter) over that of prokaryotes (0.5 to 2 microns in diameter) in Phase 1 of their evolution. Physical imitations on the size of eukaryote cells restricted further expansion of the information processing membrane surface area. If a eukaryote cell grew too large, the pressure exerted by its cytoplasmic mass would rupture the membrane and lead to cell death. As a result, after a billion years of evolution, eukaryote cell development also reached an endpoint where structural limitations prevented the incorporation of

more membrane surface area. Upon creating the Earth's most conscious organism, Phase 1 of eukaryote evolution ended.

Phase 2 of eukaryotic evolution began around 600 million years ago when eukaryote cells began to assemble into simple communities to share awareness and improve their survival. Participating eukaryote cells comprising these primitive colonies were structurally and functionally identical and display the same behavioural characteristics. As the population density of cells in these colonies grew, it was no longer efficient for all participating cells to engage in the same behaviours. The process of cell differentiation evolved to efficiently support the physiologic needs of large cellular communities.

Differentiation mechanisms enabled individual communal cells to express up to 200 different specialized functions, such as brain cells, skin cells, and heart cells in animals and xylem, phloem and cambium cells in plants. Vital physiologic systems that support the lives of individual eukaryote cells are the exact same systems needed to support the survival of the eukaryote communities that represent plants and animals. Collectively, the specialized behaviours of differentiated cells provide the community with the same vital functions required by a single cell.

All of the physiologic systems in a eukaryotic cell are replicated in plants and animals by mosaics of differentiated cells. With the exception of unicellular species, each plant and animal species comprising the web of life is actually a complexly organized, multicellular eukaryote community, distinguishable by its unique shape and behaviours.

The basic structure and functions of the eukaryote cell membrane are reproduced in multicellular animals as an epithelium. This is a multicellular tissue comprised of membrane-like layers of cells that cover external surfaces and line internal surfaces of hollow organs, such as the digestive, respiratory and urogenital tracts and blood vessels. The brain in vertebrate organisms evolves as a derivative of a specialized embryonic neural epithelium encased in the rigid skull.

Mammals are the most advanced species in the lineage of multicellular eukaryotic vertebrates. In mammals, the barrier and information processing functions of the eukaryote's cell membrane are replicated in the structure and behaviour of the embryonic ectoderm, the epithelial equivalent of a cell membrane. The ectoderm provides for two specializations in mammals, skin and nervous system, the same functions provided by the eukaryote's cell membrane. The brain in primitive mammals resembles a smooth rounded vesicle within the skull. Tracing the lineage of mammal evolution, the increase in conscious processing mechanisms is expressed as an expansion of the brain's neuroepithelial ("membrane") surface area. In accommodating physical limitations imposed by rigid skulls, the expanding neuroepithelium folds back upon itself producing the brain's characteristic folds and furrows, referred to as sulci and gyri.

Over two million years ago, a community of amoeba-like cells that formed the body of an orang-utan evolved into two new organisms, chimpanzees and primates. In a replay of evolution's Phase 1, the new primate organism underwent two million years of evolution to create the most conscious single primate. Around 150,000 years ago, the primate lineage led to the evolution of *Homo sapiens*, "wise man," and up to now, the most conscious version of a primate. Phase 1 of human evolution ended when the rigid human skull could no longer accommodate more brain surface area.

Once human beings evolved as the most conscious version of primates, the mechanism promoting further human evolution was derived from the pattern observed in Phase 2; individual humans assembled into multi-human communities to share awareness and collectively evolve consciousness. Small hunter-gatherer clans grew over time into larger communities as humans maximized the evolution potential of the mammalian lineage. In Phase 2, the evolution of human communities transitioned from families, to clans, to states and to nations.

Around 50 thousand years ago, the collective consciousness of the human community reached a critical threshold that brought forth the emergence of early technologies. In civilization's early days, the time between the appearances of new technologies was measured in periods of years. Now, the density of the human population and its collective consciousness is so great that the period between technology innovations is now measured in units of days.

Today's world crises are precipitating a major evolutionary upheaval that will profoundly alter the fate of human civilization. The chaos produced by global crises, which are symptoms of our unsustainability, is destabilizing the structure of civilization and its institutions. While the current system is collapsing, new insights, understanding, and visions offered by cultural creatives from every field of human endeavour, are pointing the ways to reorganize human civilization so we may thrive into the future. The theory of conscious evolution offered by Lamarck provides the blue print for a more enlightened future, as does our new understanding of cell evolution.

Analysis of the development of the cell membrane as the primal nervous system has revealed, as outlined above, a heretofore-unobserved repetitive pattern of evolution with two phases (FIGURE 7): Phase 1, starts with the origin of a new organism and proceeds to create the most conscious version of that organism. Phase 1 ends when physical limitations prevent further enhancement of that organism's nervous system. Phase 2 advances evolution by increasing consciousness through the assembly of individual organisms into cooperative information-sharing communities. This phase ends when the most conscious communal organization transforms into a new organism. The presence of a new organism initiates the repeat of another cycle of Phase 1 and Phase 2 that results in the expression of yet a higher level of evolution.



FIGURE 7~ *The top image shows the former scheme of Darwinian evolution as a slow linear progression. This theory has been profoundly challenged by the new science of epigenetics and the results of the Human Genome Project. The two Phases of evolution are illustrated in the lower right corner of this figure. The 3 cycles of progressions described above: 1) prokaryote to eukaryote; 2) eukaryote to human being, and 3) Human being to humanity. Civilization is currently approaching completion of its evolution into the new superorganism, humanity.*

We can get to that higher level of evolution offered in Phase 2, but only if we change our rapacious ways. The *potential* positive future our species can be likened to the metamorphosis of a butterfly. A caterpillar's body is comprised of several billion cells. In the body of the growing caterpillar, the economy is booming and the cellular community is actively employed. The voracious appetite of this organism leads to their devouring the leaves of the plant on which they are living. Caterpillar growth slows and eventually comes to an end as the available resources are consumed. Within the pupa, the cells are out of work and their highly structured community begins to fall apart. Specialized imaginal cells (the equivalent of "cultural creatives") within the ensuing chaos provide organizing information and direction to create a different, more sustainable future. Metamorphosis is complete when the non-sustainable caterpillar civilization transforms into the ecologically sensitive butterfly civilization.

The parallels are clear. By behaving as a caterpillar, human civilization's voracious appetite to grow and consume has undermined the environment and precipitated the 6th mass extinction of life. The global crises we face today are Nature's wake-up call for humans to realize that civilization needs to undergo a "metamorphosis," – the current environmentally destructive "caterpillar" version of civilization must transform into a "new" sustainable superorganism, *Humanity*. The looming fall of civilization as we know it is a necessity; we simply cannot build a future for humans to thrive on the unsustainable foundation supporting today's world. But we must keep in mind, not all caterpillars survive the metamorphosis into butterflies.

Will human civilization survive its "metamorphosis?" At the moment, civilization is balanced on the knife-edge of extinction or conscious evolution. Our uncertain future is dependent on the actions we engage in today.

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