INSIGHT INTO CELLULAR "CONSCIOUSNESS"

Though a human is comprised of over fifty trillion cells, there are no physiologic functions in our bodies that were not already pre-existing in the biology of the single, nucleated (eukaryotic) cell. Single-celled organisms, such as the amoeba or paramecium, possess the cytological equivalents of a digestive system, an excretory system, a respiratory system, a musculoskeletal system, an immune system, a reproductive system and a cardiovascular system, among others. In the humans, these physiologic functions are associated with the activity of specific organs. These same physiologic processes are carried out in cells by diminutive organ systems called organelles.

Cellular life is sustained by tightly regulating the functions of the cells physiologic systems. The expression of predictable behavioral repertoires implies the existence of a cellular "nervous system." This system reacts to environmental stimuli by eliciting appropriate behavioral responses. The organelle that coordinates the adjustments and reactions of a cell to its internal and external environments would represent the cytoplasmic equivalent of the "brain."

Since the breaking of the genetic code in the early 1950's, cell biologists have favored the concept of genetic determinism, the notion that genes "control" biology. Virtually all of the cells genes are contained within the cells largest organelle, the nucleus. Conventional opinion considers the nucleus to be the "command center" of the cell. As such, the nucleus would represent the cellular equivalent of the "brain."

Genetic determinism infers that the expression and fate of an organism are primarily "predetermined" in its genetic code. The genetic basis of organismal expression is ingrained in the biological sciences as a consensual truth, a belief by which we frame our reference for health and disease. Hence the notion that susceptibility to certain illnesses or the expression of aberrant behavior is generally linked to genetic lineage and, on occasions, spontaneous mutations. By extension, it is also perceived by a majority of scientists that the human mind and consciousness are "encoded" in the molecules of the nervous system. This in turn promotes the concept that the emergence of consciousness reflects the "ghost in the machine."

The primacy of DNA in influencing and regulating biological behavior and evolution is based upon an unfounded assumption. A seminal article by H. F. Nijhout (BioEssays 1990, 12 (9):441-446) describes how concepts concerning genetic "controls" and "programs" were originally conceived as metaphors to help define and direct avenues of research. Widespread repetition of this compelling hypothesis over fifty years has resulted in the "metaphor of the model" becoming the "truth of the mechanism," in spite of the absence of substantiative supporting evidence. Since the assumption emphasizes the genetic program as the "top rung" on the biological control ladder, genes have acquired the status of causal agents in eliciting biological expression and behavior

(e.g., genes causing cancer, alcoholism, even criminality).

The notion that the nucleus and its genes are the "brain" of the cell is an untenable and illogical hypothesis. If the brain is removed from an animal, disruption of physiologic integration would immediately lead to the organism's death. If the nucleus truly represented the brain of the cell, then removal of the nucleus would result in the cessation of cell functions and immediate cell death. However, experimentally enucleated cells may survive for two or more months with out genes, and yet are capable of effecting complex responses to environmental and cytoplasmic stimuli (Lipton, et al., Differentiation 1991, 46:117-133). Logic reveals that the nucleus can not be the brain of the cell!

Studies on cloned human cells led me to the awareness that the cells plasmalemma, commonly referred to as the cell membrane, represents the cells "brain." Cell membranes, the first biological organelle to appear in evolution, are the only organelle common to every living organism. Cell membranes compartmentalize the cytoplasm, separating it from the vagaries of the external environment. In its barrier capacity, the membrane enables the cell to maintain tight "control" over the cytoplasmic environment, a necessity in carrying out biological reactions. Cell membranes are so thin that they can only be observed using the electron microscope. Consequently, the existence and universal expression of the membrane structure was only clearly established around 1950.

In electron micrographs, the cell membrane appears as a vanishingly thin (<10nm), tri-layered (black-white-black) "skin" enveloping the cell. The fundamental structural simplicity of the cell membrane, which is identical for all biological organisms, beguiled cell biologists. For most of the last fifty years, the membrane was perceived as a "passive," semi-permeable barrier, resembling a breathable "plastic wrap," whose function was to simply contain the cytoplasm.

The membranes layered appearance reflects the organization of its phospholipid building blocks. These lollipop-shaped molecules are amphipathic, they possess both a globular polar phosphate head (Figure A) and two stick-like non-polar legs (Figure B). When shaken in solution, the phospholipids self-assemble into a stabilizing crystalline bilayer (Figure C).

The lipid legs comprising the core of the membrane provide a hydrophobic barrier (Figure D) that partitions the cytoplasm from the ever-changing external environment. While cytoplasmic integrity is maintained by the lipids passive barrier function, life processes necessitate the active exchange of metabolites and information between the cytoplasm and surrounding environment. The physiologic activities of the plasmalemma are mediated by the membranes proteins .

Each of the approximately 100,000 different proteins providing for the human body is comprised of a linear chain of linked amino acids. The "chains" are assembled from a population of twenty different amino acids. Each proteins unique structure and function is defined by the specific sequence of amino acids comprising its chain. Synthesized as a linear string, the amino acid chains subsequently fold into unique three dimensional globules. The final conformation (shape) of the protein reflects a balance of electrical charges among its constituent amino acids.

The three dimensional morphology of folded proteins endows their surfaces with specifically shaped clefts and pockets. Molecules and ions possessing complementary physical shapes and electrical charges will bind to a proteins surface clefts and pockets with the specificity of a lock-and-key. Binding of another molecule alters the proteins electrical charge distribution. In response, the proteins amino acid chain will spontaneously refold to rebalance the charge

distribution. Refolding changes the proteins conformation. In shifting from one conformation to the next, the protein expresses movement. Protein conformational movements are harnessed by the cell to carry out physiologic functions. The work generated by protein movement is responsible for "life."

A number of the twenty amino acids comprising the proteins chain are non-polar (hydrophobic, oil-loving). The hydrophobic portions of proteins seek stability by inserting themselves into the membranes lipid core. The polar (water-loving) portions of these proteins extend from either or both of the membranes water-covered surfaces. Proteins incorporated within the membrane are called integral membrane proteins (IMPs).

Membrane IMPs can be functionally subdivided into two classes: receptors and effectors. Receptors are input devices that respond to environmental signals. Effectors are output devices that activate cellular processes. A family of processor proteins, located in the cytoplasm beneath the membrane, serve to link signal-receiving receptors with action-producing effectors.

Receptors are molecular "antennas" that recognize environmental signals. Some receptor antennas extend inward from the membranes cytoplasmic face. These receptors "read" the internal milieu and provide awareness of cytoplasmic conditions. Other receptors extending from the cells outer surface provide awareness of external environmental signals.

Conventional biomedical sciences hold that environmental "information" can only be carried by the substance of molecules (Science 1999, 284:79-109). According to this notion, receptors only recognize "signals" that physically complement their surface features. This materialistic belief is maintained even though it has been amply demonstrated that protein receptors respond to vibrational frequencies. Through a process known as electroconformational coupling (Tsong, Trends in Biochem. Sci. 1989, 14:89-92), resonant vibrational energy fields can alter the balance of charges in a protein. In a harmonic energy field, receptors will change their conformation. Consequently, membrane receptors respond to both physical and energetic environmental information.

A receptors "activated" conformation informs the cell of a signals existence. Changes in receptor conformation provide for cellular "awareness." In its "activated" conformation, a signal-receiving receptor may bind to either a specific function-producing effector protein or to intermediary processor protein. Receptor proteins return to their original "inactive" conformation and detach from other proteins when the signal ceases.

The family of effector proteins represent "output" devices. There are three different types of effectors, transport proteins, enzymes and cytoskeletal proteins. Transporters, which include the extensive family of channels, serve to transport molecules and information from one side of the membrane barrier to the other. Enzymes are responsible for metabolic synthesis and degradation. Cytoskeletal proteins regulate the shape and motility of cells.

Effector proteins generally possess two conformations: an active configuration in which the protein expresses its function; and a "resting" conformation in which the protein is inactive. For example, a channel protein in its active conformation possesses an open pore through which specific ions or molecules traverse the membrane barrier. In returning to an inactive conformation, protein refolding constricts the conducting channel and the flow of ions or molecules ceases.

Putting all the pieces together we are provide with insight as to how the cells "brain" processes information and elicits behavior. The innumerable molecular and radiant energy signals in a cell's environment creates a virtual cacophony of information. In a manner resembling a biological Fourier transform, individual surface receptors (Fig. H) sense the apparently chaotic environment and filter out specific frequencies as behavioral signals. Receipt of a resonant signal (Fig. I, arrow) induces a conformational change in the cytoplasmic portion of the receptor (Fig. I, arrowhead). This conformational change enables the receptor to complex with a specific effector IMP (Fig. J, in this case a channel IMP). Binding of the receptor protein (Fig. K) in turn elicits a conformational change in the effector protein (Fig. L, channel opens). Activated receptors can turn on enzyme pathways, induce structural reorganization and motility or activate transport of uniquely pulsed electrical signals and ions across the membrane.

Processor proteins serve as "multiplex" devices in that they can increase the versatility of the signal system. Such proteins interface receptors with effector proteins (P in figure M). By "programming" processor protein coupling, a variety of inputs can be linked with a variety of outputs. Processor proteins provide for a large behavioral repertoire using a limited number of IMPs.

Effector IMPs convert receptor-mediated environmental signals into biological behavior. The output function of some effector proteins might represent the full extent of an elicited behavior. However, in most cases, the output of effector IMPs actually serve as a secondary "signal" which penetrates the cell and activates behavior of other cytoplasmic protein pathways. Activated effector proteins also serve as transcription factors, signals that elicit gene expression.

The behavior of the cell is controlled by the combined actions of coupled receptors and effector IMPs. Receptors provide "awareness of the environment" and effector proteins convert that awareness into "physical sensation." By strict definition, a receptor-effector complex represents a fundamental unit of perception. Protein perception units provide the foundation of biological consciousness. Perceptions "control" cell behavior, though in truth, a cell is actually "controlled" by beliefs, since perceptions may not necessarily be accurate.

The cell membrane is an organic information processor. It senses the environment and converts that awareness into "information" that can influence the activity of protein pathways and control the expression of the genes. A description of the membranes structure and function reads as follows: (A) based upon the organization of its phospholipid molecules, the membrane is a liquid crystal; B) the regulated transport of information across the hydrophobic barrier by IMP effector proteins renders the membrane a semiconductor; and (C) the membrane is endowed with IMPs that function as gates (receptors) and channels. As a liquid crystal semiconductor with gates and channels, the membrane is an information processing transistor, an organic computer chip.

Each receptor-effector complex represents a biological BIT, a single unit of perception. Though this hypothesis was first formally presented in 1986 (Lipton 1986, Planetary Assoc. for Clean Energy Newsletter 5:4), the concept has since been technologically verified. Cornell and others (Nature 1997, 387:580-584), linked a membrane to a gold foil substrate. By controlling the electrolytes between the membrane and the foil, they were able to digitize the opening and closing of receptor-activated channels. The cell and a chip are homologous structures.

The cell is a carbon-based "computer chip" that reads the environment. Its "keyboard" is comprised of receptors. Environmental information is entered via its protein "keys". The data is

transduced into biological behavior by effector proteins. The IMP BITs serve as switches that regulate cell functions and gene expression. The nucleus represents a "hard disk" with DNA-coded software. Recent advances in molecular biology emphasize the read/write nature of this hard drive.

Interestingly, the thickness of the membrane (about 7.5 nm) is fixed by the dimensions of the phospholipid bilayer. Since membrane IMPs are approximately 6-8 nm in diameter, they can only form a monolayer in the membrane. IMP units can not stack upon one another, the addition of more perception units is directly linked to an increase in membrane surface area. By this understanding, evolution, the expansion of awareness (i.e., the addition of more IMPs) would most effectively be modeled using fractal geometry. The fractal nature of biology can be observed in the structural and functional reiterations observed among the hierarchy of the cell, multicellular organisms (man) and the communities of multicellular organisms (human society).

This new perception on cell control mechanisms frees us from the limitations of genetic determinism. Rather than behaving as programmed genetic automatons, biological behavior is dynamically linked to the environment. Though this reductionist approach has highlighted the mechanism of the individual perception proteins, an understanding of the processing mechanism emphasizes the holistic nature of biological organisms. The expression of the cell reflects the recognition of all perceived environmental stimuli, both physical and energetic. Consequently, the "Heart of Energy Medicine" may truly be found in the magic of the membrane.