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Three Laws of Biology

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> "Social rules can be broken, but the laws of nature can't."

Immense scientific progress has been made in recent centuries, and the time period required to double our knowledge continues to shrink. In recent decades, the sequencing of genomes from diverse species has been a primary driving force behind the expansion of biological knowledge. It has become central to the study of molecular and organismal evolution. The technologies that, for example, enable genomics, molecular medicine, and computing to forge forward at such rapid interdependent paces, are recognized as central to our understanding of Earth's biosphere and sustaining it for future generations.

In recent years, biology has been at the forefront of science as we satisfy our desires to understand the nature of living organisms and their evolutionary histories. The statements that follow are based on reams of evidence. Only when each statement is integrated with the others does a reasonably complete picture of life become possible. We enlist the assistance of the international scientific community to inform us of any modifications and exceptions to existing scientific dogma so that our concepts can continuously be refined. Only via this approach has it been possible to establish some basic laws of biology. The First Law of Biology: all living organisms obey the laws of thermodynamics. The Second Law of Biology: all living organisms consist of membrane-encased cells. The Third Law of Biology: all living organisms arose in an evolutionary process.

The First Law of Biology: all living organisms obey the laws of thermodynamics. This law is fundamental because the laws of the inanimate world determine the course of the universe. All organisms on all planets, including humans, must obey these laws. The laws of thermodynamics govern energy transformations and mass distributions. Cells that comprise living organisms (see The Second Law) are open systems that allow both mass and energy to cross their membranes. Cells exist in open systems so as to allow acquisition of minerals, nutrients, and novel genetic traits while extruding end products of metabolism and toxic substances. Genetic variation, which results in part from gene transfer in prokaryotes and sexual reproduction in higher organisms, allows tremendously increased phenotypic variability in a population as well as an accelerated rate of evolutionary divergence.

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A corollary of the First Law is that life requires the temporary creation of order in apparent contradiction to the second law of thermodynamics. However, considering a completely closed system, including the materials and energy sources provided by the environment for the maintenance of life, living organisms affect the system strictly according to this law, by increasing randomness or chaos (entropy). Resource utilization by living organisms thus increases the entropy of the world. A second corollary of the First Law is that an organism at biochemical equilibrium is dead. When living organisms reach equilibrium with their surrounding environment, they no longer exhibit the quality of life. Life depends on interconnected biochemical pathways to allow for growth, macromolecular synthesis, and reproduction. Thus, all life forms are far from equilibrium with their environments.

The Second Law of Biology: all living organisms consist of membrane-encased cells. Enveloping membranes allow physical separation between the living and the non-living worlds. Viruses, plasmids, transposons, prions, and other selfish, biological entities are not alive. They cannot "self" reproduce. They are dependent on a living cell for this purpose. By definition, they therefore, are not alive. A corollary of the Second Law is that the cell is the only structure that can grow and divide independently of another life form. A second corollary of the Second Law is that all life is programmed by genetic instructions. Genetic instructions are required for cell division, morphogenesis, and differentiation. From single-celled prokaryotic organisms to normal or cancerous tissues in multicellular animals and plants, genetic instructions are required for the maintenance of life.

The Third Law of Biology: all living organisms arose in an evolutionary process. This law correctly predicts the relatedness of all living organisms on Earth. It explains all of their programmed similarities and differences. Natural selection occurs at organismal (phenotypic) and molecular (genotypic) levels. Organisms can live, reproduce, and die. If they die without reproducing, their genes are usually removed from the gene pool, although exceptions exist. At the molecular level, genes and their encoding proteins can evolve "selfishly," and these can combine with other selfish genes to form selfish operons, genetic units and functional parasitic elements such as viruses.

Two corollaries of the Third Law are that (1) all living organisms contain homologous macromolecules (DNA, RNA, and proteins) that derived from a common ancestor, and (2) the genetic code is universal. These two observations provide compelling evidence for the Third Law of Biology. Because of his accurate enunciation of the Third Law, Charles Darwin is considered by many to be the greatest biologist of all time.

Although science is continually pushing back the frontiers of our knowledge, we will never know everything. In fact, we do not even know what we do not know. For example, we may never know how life arose. Although life may be sprinkled throughout the universe, life is not required for the continuity of inanimate matter; that is, living organisms are not essential for the universe to function. The laws of physics continue to apply regardless of the presence of life. To the best of our knowledge, life can only arise from pre-existing life. This of course begs the question how the first living cell(s) might have arisen. Did life spontaneously arise from inanimate nature just once, or more than once? Can life be transferred between receptive planets through space travel? We simply do not know. The mechanisms that may have led to the origin of a cell capable of autonomous growth and division are a mystery. This is an area of biology that will require a tremendous amount of scientific research if evidence is ever to become available, and there are no guarantees.

The rules of biology and science cannot be broken. They are not artificial human-made laws. They are natural laws that govern all life while living organisms are evolving on our planet. In recent decades, humans have altered our common, shared biosphere with resource depletion and pollution. We know that these activities have upset the balance of Nature, causing extensive species extinction. The most significant forms of pollution can be attributed to too many humans consuming too many non-renewable resources at an ever-increasing rate. Much of this harm is driven by pleasure, greed, conflict, and the desire for power. To varying degrees, we are all to blame.

Why do so many people assault the biosphere in such a primitive manner? Some are ignorant of the outcome. They are oblivious to the consequences of their actions. They do not recognize that incorrect action can have disastrous outcomes for our biosphere and us all. They do not understand that natural selection is cruel and can cause immense suffering and death. They think only of the moment and refuse

to accept that it is their offspring who will have to face calamity. Still others are fully aware of the ultimate consequences. And those of us who are aware must take action to pass on our knowledge so as to attempt to avoid or delay our self-imposed fate. Research *does* tell us that we are assaulting our biosphere, and that the planet cannot accommodate our huge human population. We depend on natural resources for the continuance of our existence, but we are not living-sustainable. This planet does not need more consumption and pollution. It is groaning under the weight of our ever-increasing human population. Entropy will have its way. It might help if everyone understood science and our natural world so that they would recognize what is required for survival of the human species with some reasonable quality of life; and the first step in this direction is to understand the basic laws of physics, chemistry, and biology and how they govern our biosphere, which is currently under assault and in need of being rescued. However, without profound respect for Nature and compassion for life, all life, knowledge is likely to be insufficient. We must develop into more caring, sensitive, and compassionate beings.